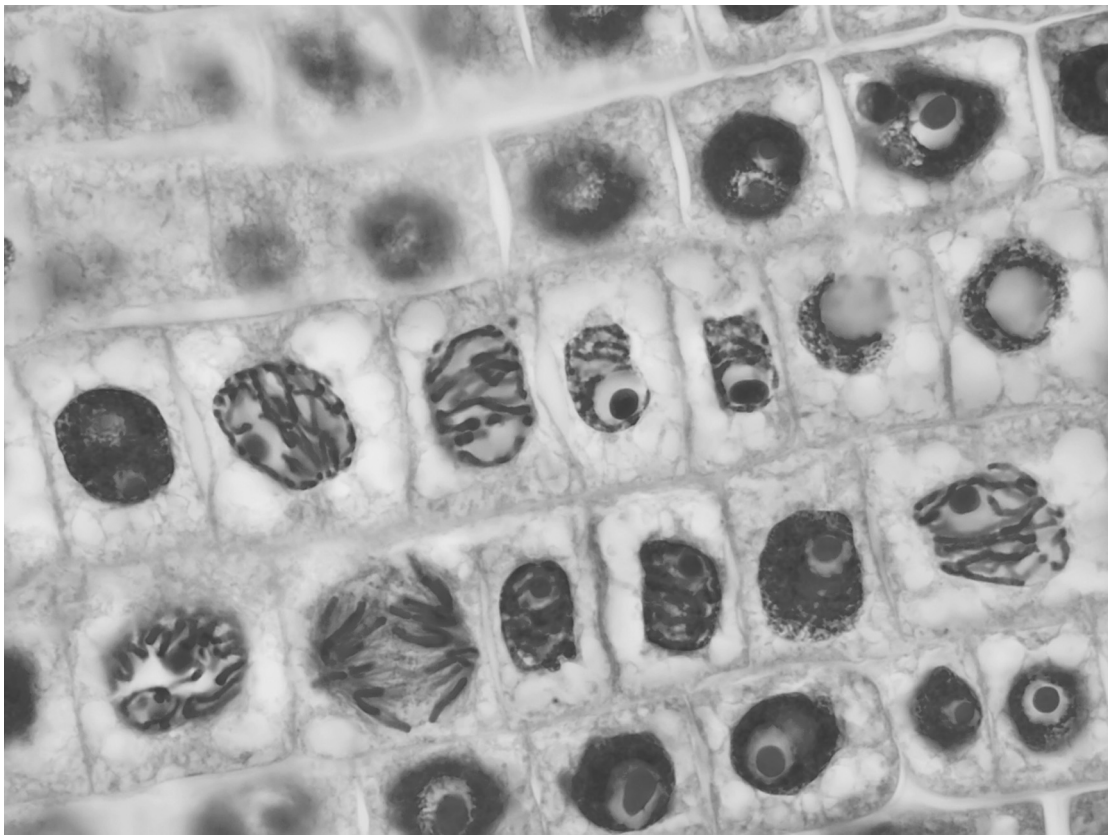
A LEVEL Biology

5. The Mitotic Cell Cycle

Paper 2



Classified by Mr.Adeel Ahmad

5 The slime mould, *Dictyostelium discoideum*, is a eukaryote and a decomposer of protein-rich material.

For Examiner's Use

Fig. 5.1 shows the life cycle of *D. discoideum*.

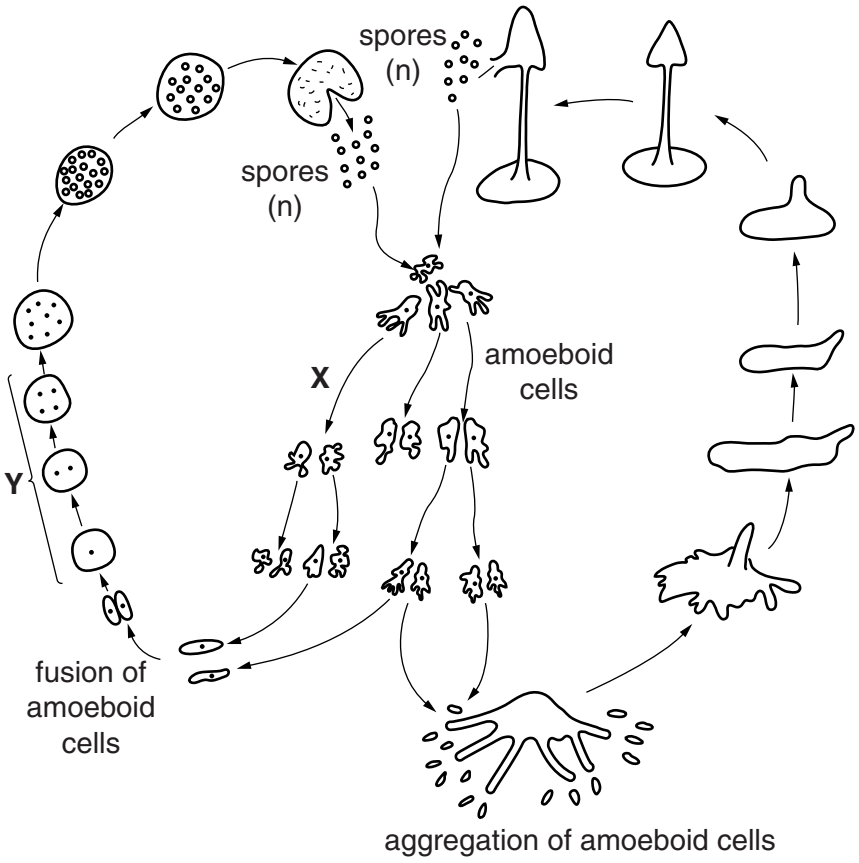


Fig. 5.1

(a) State the type of nuclear division that occurs at **X** and at **Y**.

X .....

Y .....[1]

(b) State what is meant by the term *reduction division* **and** explain why this division is necessary in a life cycle, such as that shown in Fig. 5.1.

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.....[2]

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(c) The amoeboid cells of *D. discoideum* feed on protein-rich material and break it down to form ammonium ions (NH_4^+). The cell membranes of *D. discoideum* have transporter proteins that are responsible for the excretion of ammonium ions.

For Examiner's Use

Describe what happens to the ammonium ions excreted by *D. discoideum* into the soil.

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.....[3]

REMOVED FROM THE SYLLABUS

(d) Suggest why a transporter protein is required for the removal of ammonium ions from *D. discoideum*.

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.....[2]

[Total: 8]

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(b) An activated B-lymphocyte divides repeatedly by mitosis to produce many identical plasma cells.

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(i) Explain why it is important that many identical plasma cells are produced.

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..... [3]

(ii) B-lymphocytes have centrioles and a spindle that can be observed during mitosis.

Describe and explain how the behaviour of the centrioles and spindle of a cell dividing by mitosis is associated with the behaviour of the chromosomes.

You may use the space below for labelled diagrams.

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..... [4]

[Total: 13]

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3 Bone marrow contains stem cells that divide by mitosis to form blood cells. Each time a stem cell divides it forms a replacement stem cell and a cell that develops into a blood cell.

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Fig. 3.1 shows changes in the mass of DNA in a human stem cell from the bone marrow during three cell cycles.

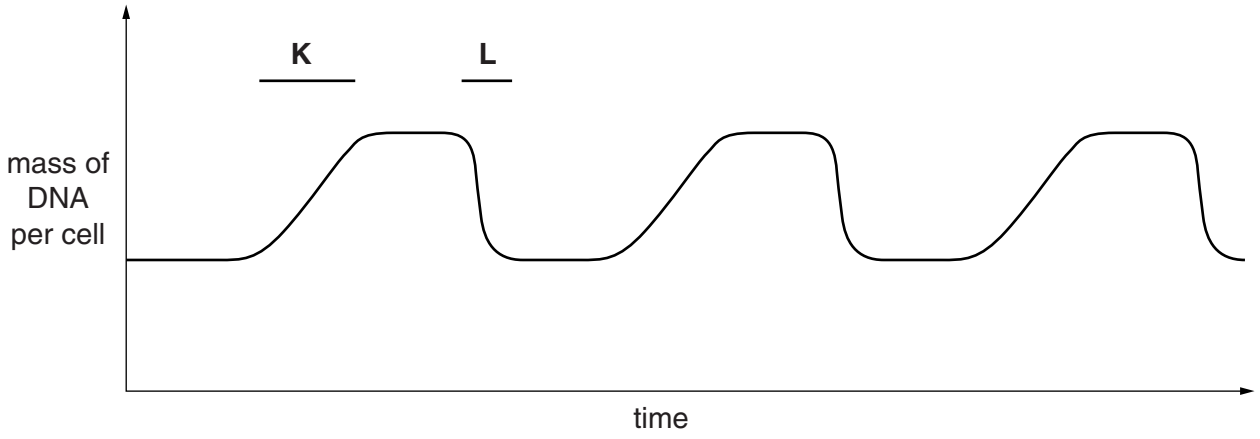

Fig. 3.1

(a) With reference to Fig. 3.1, state:

(i) what happens to bring about the changes in the mass of DNA per cell at **K** and at **L**

K .....

.....

L .....

.....[2]

(ii) how many blood cells are formed from the stem cell in the time shown

.....[1]

(iii) what happens to the number of chromosomes in the stem cell.

.....[1]

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Answer **all** the questions.

For Examiner's Use

1 **(a)** The cells in Fig. 1.1 are from the same organism and look the same. The cells in Fig. 1.1(a) have been produced by mitosis and the cells in Fig. 1.1(b) have been produced by meiosis**.**

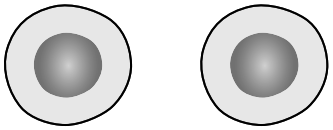

Fig. 1.1(a)

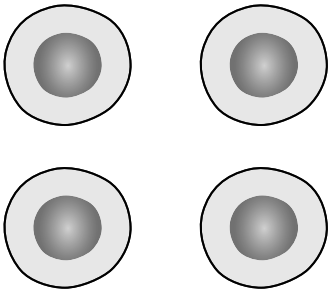

Fig. 1.1(b)

(i) Complete the table to show two differences between cells that have been produced by mitosis compared to cells that have been produced by meiosis.

mitosis	**meiosis**

[2]

(ii) Explain why the organism produces cells by meiosis.

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..... [2]

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5 **(a)** Explain the importance of mitosis in multicellular organisms.

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..... [3]

A protein, mitosis-promoting factor (MPF), has been identified in cells. MPF is a globular protein made from two polypeptide chains.

(b) Place a tick (✓) in the box next to the type, or types, of protein structure shown by MPF.

primary	☐
secondary	☐
tertiary	☐
quaternary	☐

[1]

The presence of MPF is known to cause prophase to start.

(c) Describe the changes that occur during prophase in an animal cell.

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..... [4]

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(d) MPF normally begins to break down and stops functioning during anaphase.

Suggest the possible consequences of MPF **not** breaking down.

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..... [3]

[Total: 11]

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Answer **all** the questions.

For Examiner's Use

1 Fig. 1.1 shows a cell of a female fruit fly, *Drosophila melanogaster*, during a stage of mitosis.

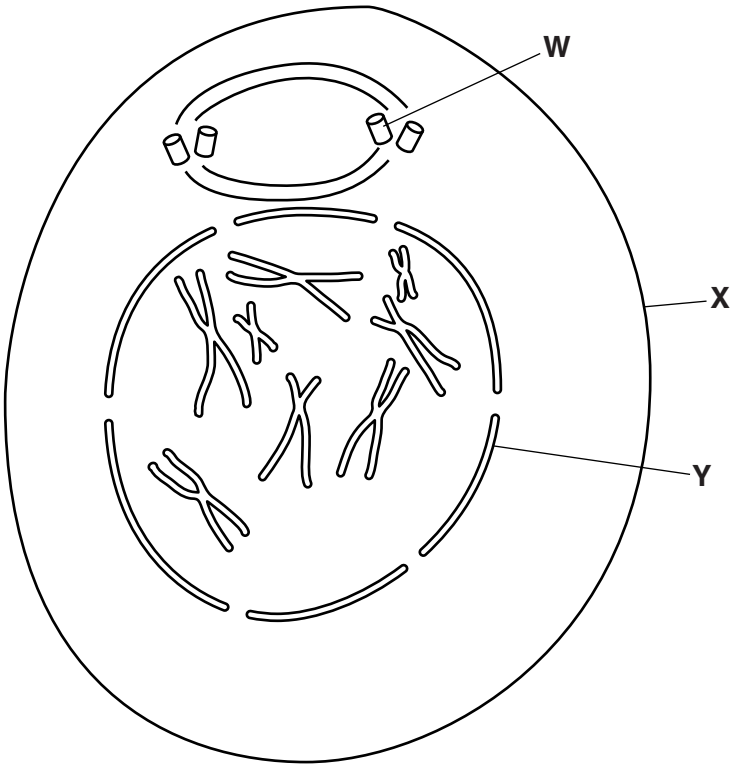

Fig. 1.1

(a) (i) Name the stage of mitosis shown in Fig. 1.1.

.....[1]

(ii) Shade a pair of homologous chromosomes. [1]

(iii) Name the structure labelled **W** and state its function.

.....

.....

.....[2]

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(b) State what happens to structure **X** and to structure **Y** between the stage shown in Fig. 1.1 and the end of cell division.

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.....[3]

[Total: 7]

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(d) The inner lining of arteries and veins is composed of a layer of epithelial cells supported by a layer of elastic and connective tissue. The epithelial cells are capable of cell division by mitosis.

(i) State the role of mitosis in cell division of epithelial cells.

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.....[2]

(ii) Explain why the epithelial cells undergo mitosis and **not** meiosis.

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.....[2]

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(e) Fig. 1.2 is a diagram of a cell in late prophase of mitosis.

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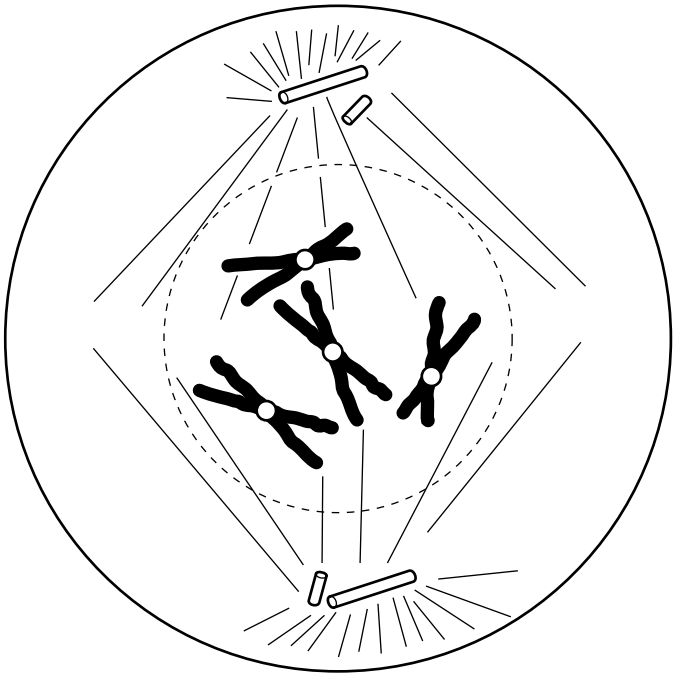

Fig. 1.2

Complete Fig. 1.3 to show the **same cell** in the **anaphase** stage of mitosis.

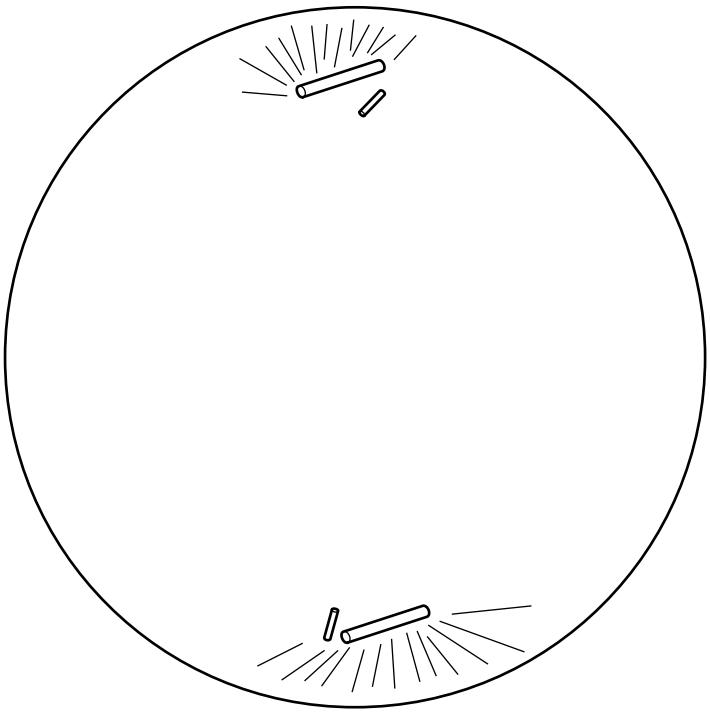

Fig. 1.3

[2]

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3 Fig. 3.1 is a photomicrograph of two animal cells, **A** and **B**, at different stages of the mitotic cell cycle.

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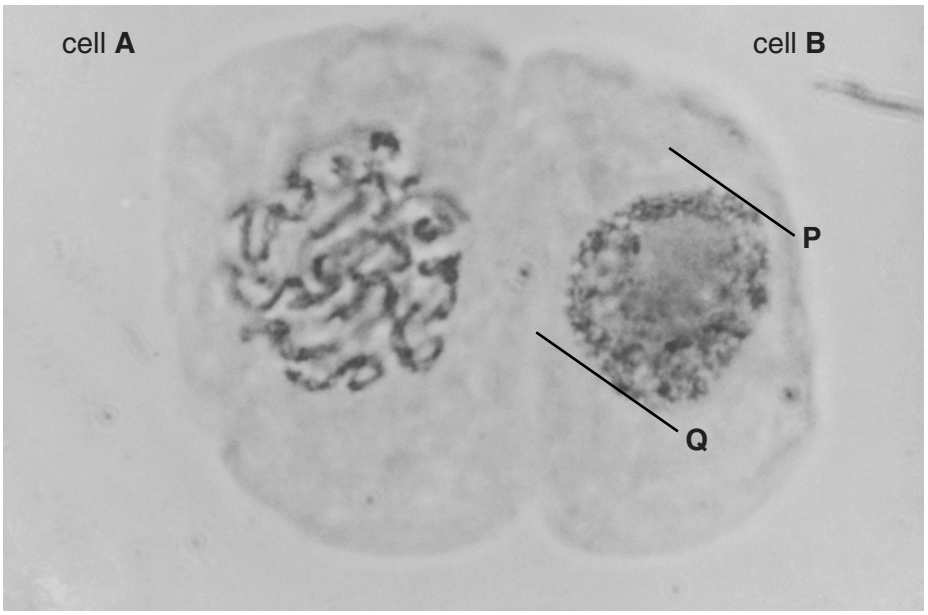

magnification ×5000

Fig. 3.1

(a) (i) For each cell, state the name of the stage of the cell cycle shown in Fig. 3.1.

cell **A** .....

cell **B** .....

[2]

(ii) Describe the events that occur during the stage of the cell cycle named for cell **A** in **(a)(i)**.

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..... [4]

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The mass of DNA in the cells shown in Fig. 4.1 was determined. The results are shown in Fig. 4.2.

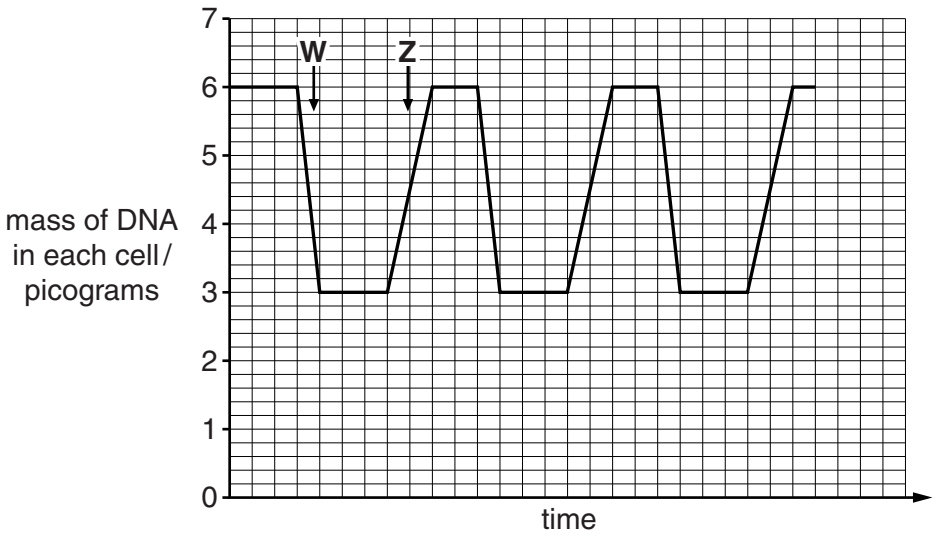

Fig. 4.2

(d) State what happens at **W** and **Z** to change the mass of DNA in each cell.

W .....

Z .....

[2]

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(c) HIV infects cells of the immune system, particularly helper T-lymphocytes (T_h cells). HIV can infect both non-dividing and dividing helper T-lymphocytes, including memory cells.

The onset of disease, which can occur many years later, coincides with a severely lowered primary and secondary immune response, owing to greatly reduced numbers of T_h cells in the body.

(i) An infected T_h cell can still carry out a normal cell cycle and divide to produce two cells.

The following processes occur during one cell cycle:

DNA replication **mitosis** **growth** **cytokinesis**

List the processes in a correct sequence.

1. .....

2. .....

3. .....

4. .....

[1]

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4 **(a)** A student cut thin sections of a root tip of *Allium cepa* and stained them to show chromosomes. A photomicrograph of part of one of these sections is shown in Fig. 4.1.

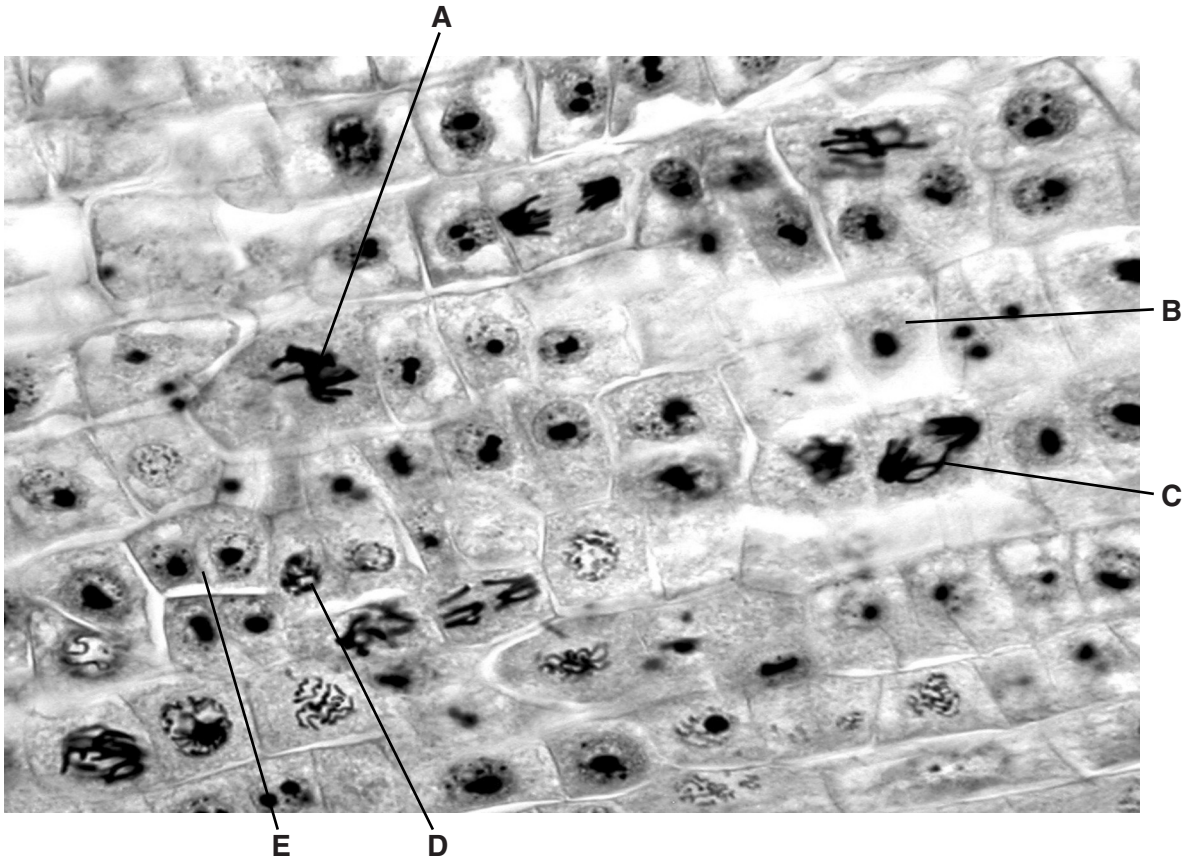

Fig. 4.1

Table 4.1 shows the behaviour of chromosomes and the changes that occur to the nuclear envelope during a mitotic cell cycle in the root tip of *A. cepa*.

Complete Table 4.1.

Table 4.1

name of stage	cell in Fig. 4.1	behaviour of chromosomes	nuclear envelope
	B	chromosomes uncoiled, may be replicating	intact
prophase			intact, but then breaks down
metaphase			not present
anaphase		chromosomes / chromatids, moving to opposite poles	
telophase		chromosomes uncoiling	

[5]

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(b) Explain why the growth of roots, such as those of *A. cepa*, involves mitosis and **not** meiosis.

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.....[3]

(c) State two processes, **other than growth**, in which mitosis is involved.

1. .....

2. .....
[2]

[Total: 10]

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6 *Agrobacterium tumefaciens* is a bacterium that can enter plants through wounds and cause a disease known as crown gall disease.

The bacterium attaches to the surface of cells and inserts a small circular DNA molecule, known as a plasmid, into the cell. Some of the genes on the plasmid code for proteins that cause changes in the plant cell and result in the formation of a plant tumour, or gall.

(a) Outline the changes that occur during tumour formation.

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..... [4]

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Answer **all** the questions

1 Fig. 1.1 is a photomicrograph of plant root cells near the growing tip. Some of the cells are undergoing mitosis.

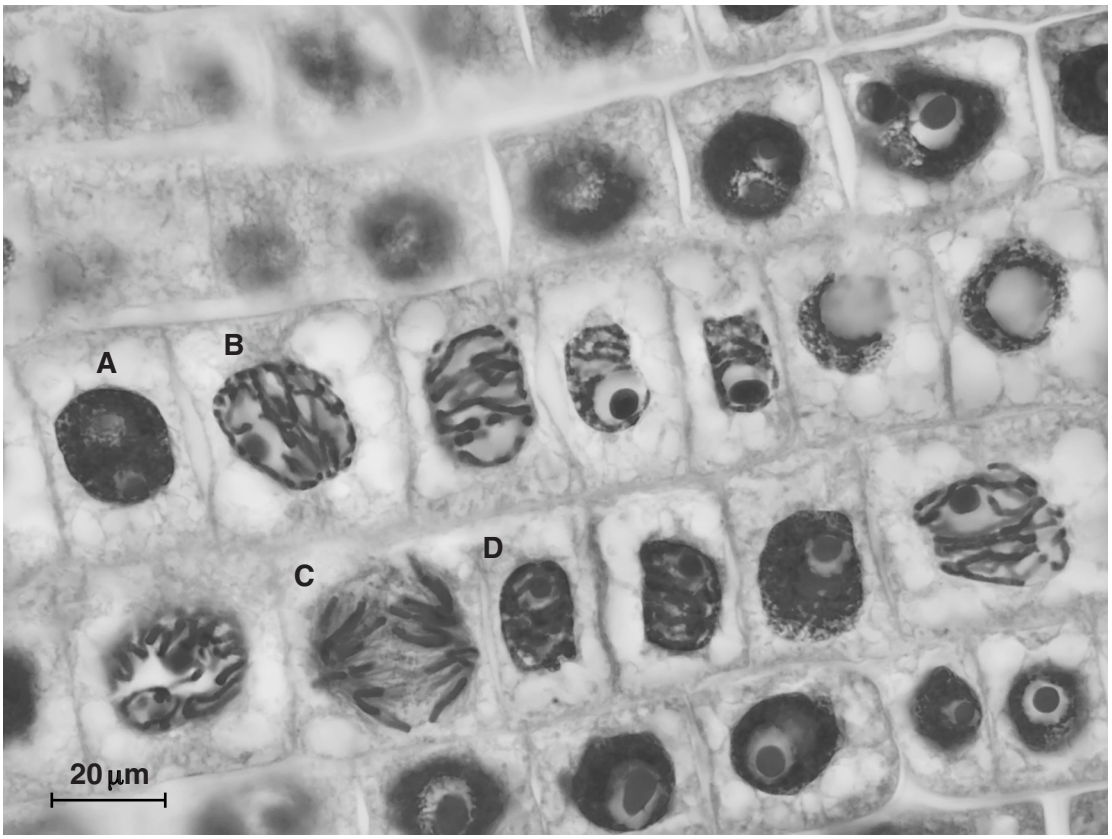

Fig. 1.1

(a) State **one** feature, visible in Fig. 1.1, which indicates that the section is taken from plant tissue and not animal tissue.

.....

.....[1]

(b) State the letter, **A** to **D**, of the cell in Fig. 1.1 which is in:

(i) prophase .....

(ii) anaphase. ..... [2]

(c) Describe two events occurring in cell **B**.

1. .....

.....

2. .....

.....

[2]

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(d) (i) Describe the role of mitosis in a growing plant root tip.

.....

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.....

.....

..... [2]

(ii) Mutations can sometimes occur in cells which are rapidly dividing.

Outline how a mutation can cause an altered polypeptide to be produced.

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.....

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..... [2]

(e) Calculate the magnification of Fig. 1.1.

Show your working and give your answer to the nearest whole number.

magnification × .....
[2]

[Total: 11]

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(ii) Mutations that occur in dividing cells of the gas exchange system may result in lung cancer.

Suggest the differences in the cell cycle of a cancer cell compared with that of a normal cell of the same type.

.....

.....

.....

.....

.....[2]

[Total: 7]

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3 Fig. 3.1 is a light micrograph of cells in the root tip of the garlic plant *Allium sativum*. It has a diploid number (2n) of 16.

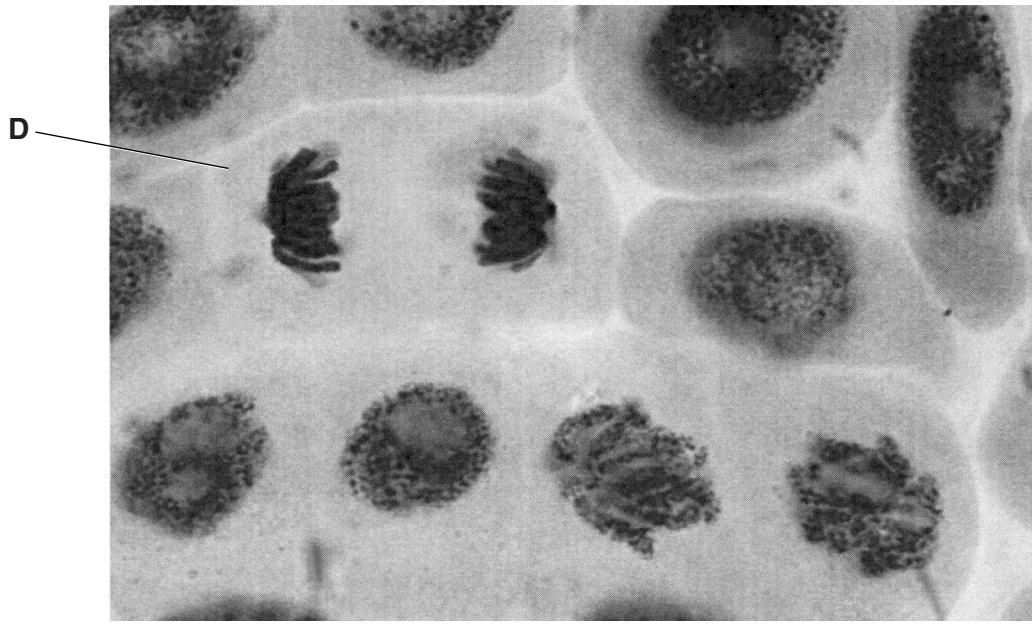

Fig. 3.1

(a) Name the stage of mitosis shown in cell **D**.

..... [1]

(b) Explain why mitosis occurs in a plant such as *A. sativum*.

.....

.....

.....

.....

..... [2]

(c) **(i)** State the haploid number of *A. sativum*.

..... [1]

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(ii) Explain why a plant such as *A. sativum* produces haploid cells.

.....

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.....

..... [3]

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3 The photomicrographs in Fig. 3.1 show stages of the mitotic cell cycle occurring in the root tip of the onion, *Allium sp*. They are all of the same magnification. Stages **A** to **C** are in the correct sequence and stages **K** to **N** are **not** in the correct sequence.

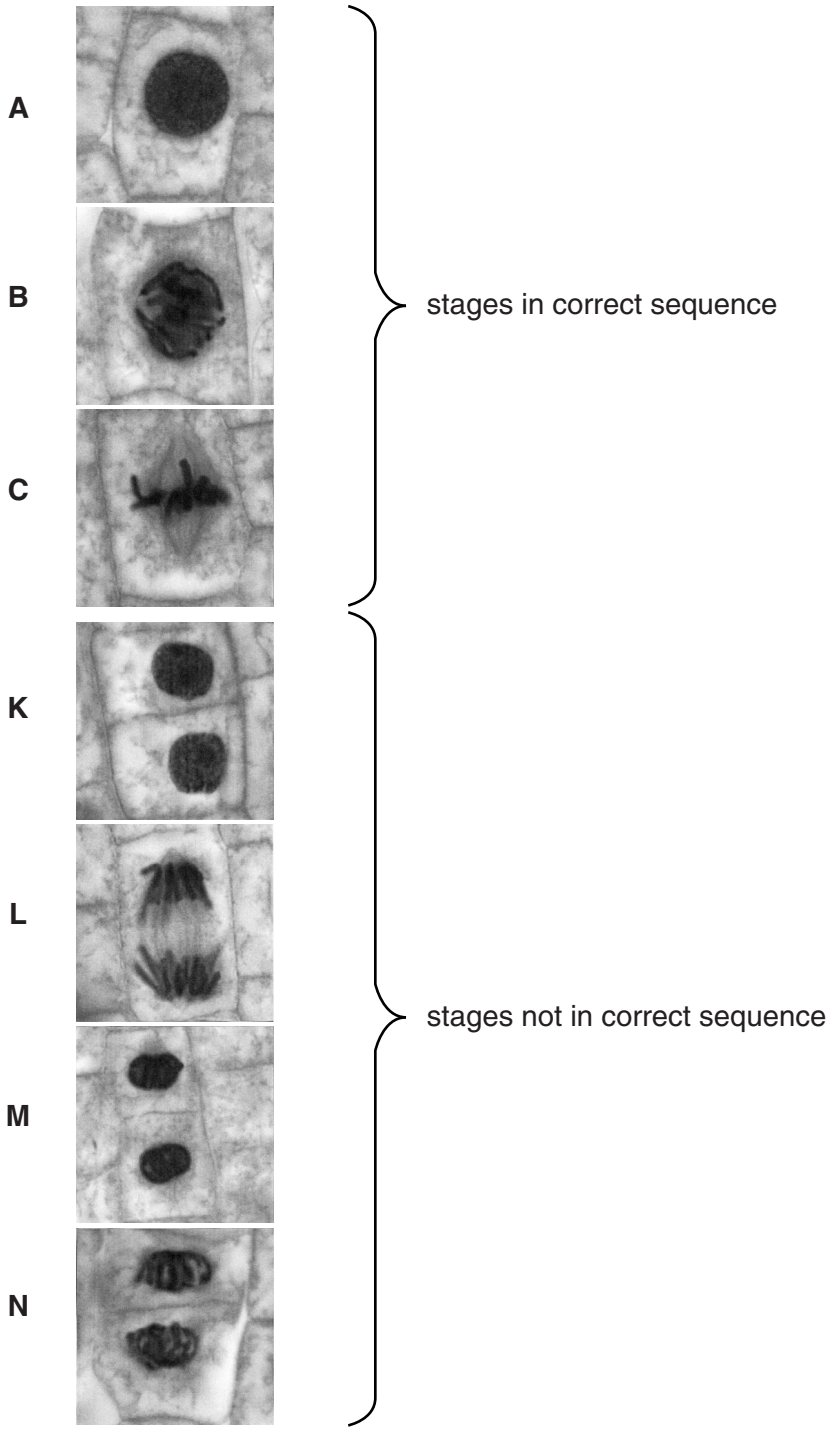

Fig. 3.1

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(a) Name stages **A** and **C**.

A .....

C ..... [1]

(b) Put stages **K** to **N** in the correct sequence, starting with the stage that immediately follows stage **C**.

C ⟶ ..... ⟶ ..... ⟶ ..... ⟶ ..... [1]

(c) Explain how the behaviour of the chromosomes and spindle during stage **L** in Fig. 3.1 ensures that the two daughter cells will be genetically identical.

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..... [3]

[Total: 5]

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Answer **all** the questions.

1 Fig. 1.1 shows four animal cells in different stages of the mitotic cell cycle.

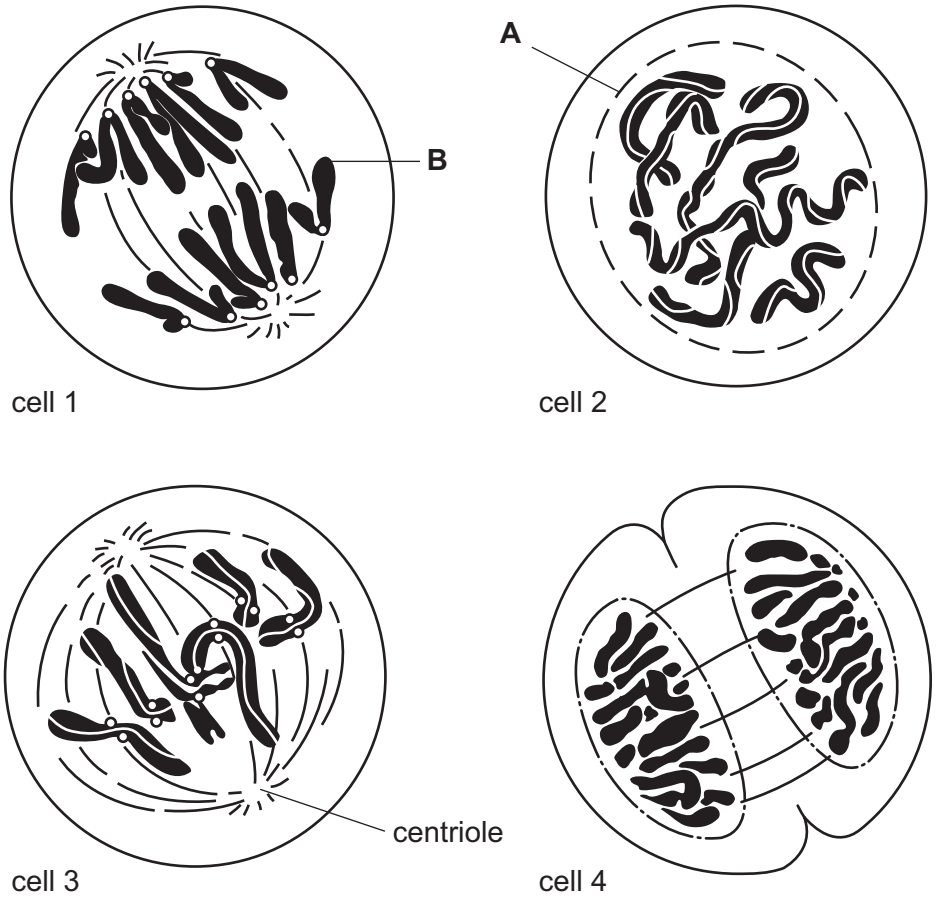

Fig 1.1

(a) Using the number given to each cell in Fig. 1.1, arrange the stages as they occur in the mitotic cell cycle.

..... [1]

(b) **(i)** State what is occurring at **A** in cell 2.

.....

..... [1]

(ii) Label **B** is pointing to a region of the chromatid that contains repetitive nucleotide sequences.
State the name given to this region.

..... [1]

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(ii) Outline the role of microtubules in mitosis.

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..... [2]

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3.(c) Red blood cells originate from undifferentiated cells in the bone marrow that are capable of continuous mitotic cell division.

State the name of this type of undifferentiated cell.

.....[1]

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5 **(a)** Fig. 5.1 is a diagram of part of an animal cell in a stage of mitosis.

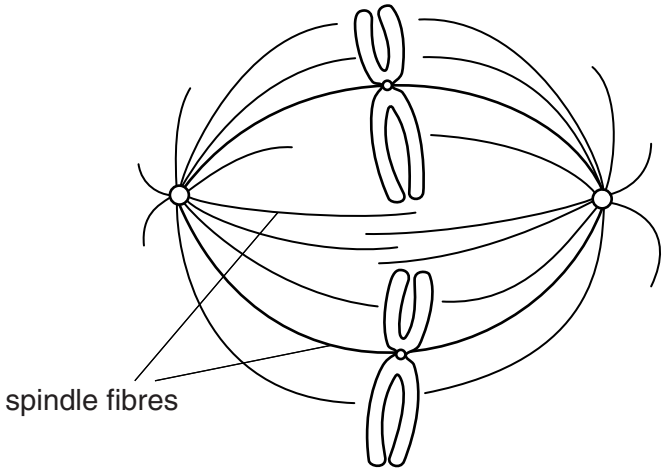

Fig. 5.1

(i) Draw a diagram in the space below to show the stage of mitosis that follows the stage in Fig. 5.1.

[3]

(ii) Describe the roles of the spindle fibres during mitosis.

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.....[2]

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Bone marrow contains many stem cells. Some of these stem cells are responsible for the replacement of red blood cells.
During the production of red blood cells a series of changes occur to the cell structure.

Fig. 5.2 shows the production of a red blood cell from one of these stem cells.

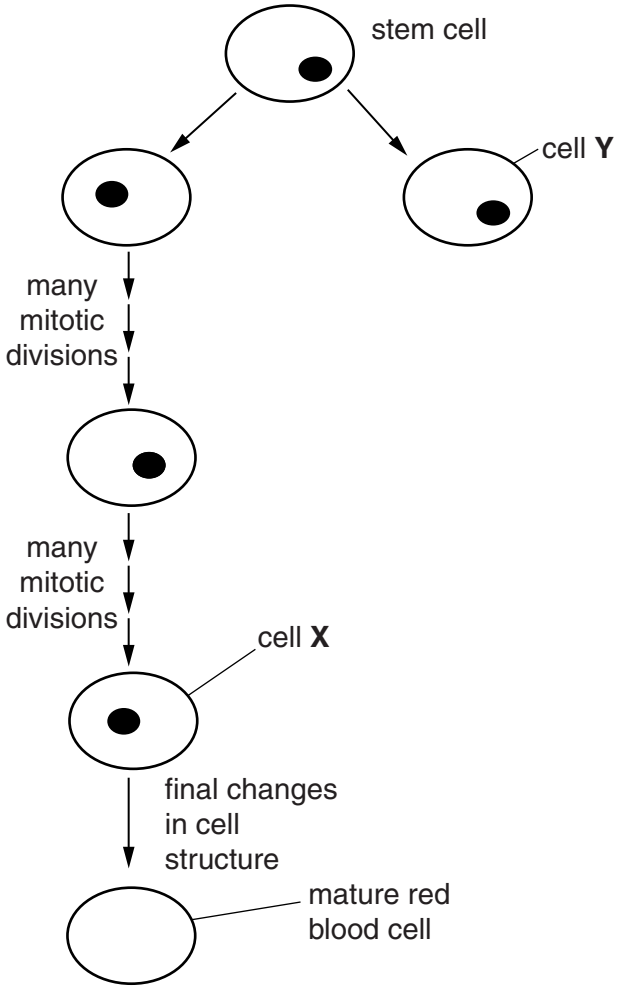

Fig. 5.2

(b) (i) Outline the changes that occur as cell **X** becomes a mature red blood cell.

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.....

.....[3]

(ii) Suggest what may happen to cell **Y**.

.....[1]

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5 Fig. 5.1 shows plant cells in stages of mitosis.

Fig. 5.1

(a) Individual chromosomes cannot be seen in the cell at the start of prophase. Changes to the chromatin occur so that by late prophase chromosomes are clearly visible.

(i) Outline what occurs during early prophase so that chromosomes become visible in late prophase.

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.....[1]

(ii) Describe the structure of the chromosome in late prophase.

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.....[3]

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(b) State **two** differences between the chromosome at metaphase and the chromosome at late anaphase.

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.....[2]

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1 Fig. 1.1 is a transmission electron micrograph of part of an animal cell.

Fig. 1.1

(c) Cells such as that in Fig. 1.1 can divide by mitosis.

Describe the role of centrioles in mitosis.

.....

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.....[2]

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5 **(ii)** In a person with lung cancer one or more healthy cells undergo changes to produce cancerous cells that can form a tumour.

Suggest **and** explain the cellular changes that occur in the development of lung cancer.

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.....[4]

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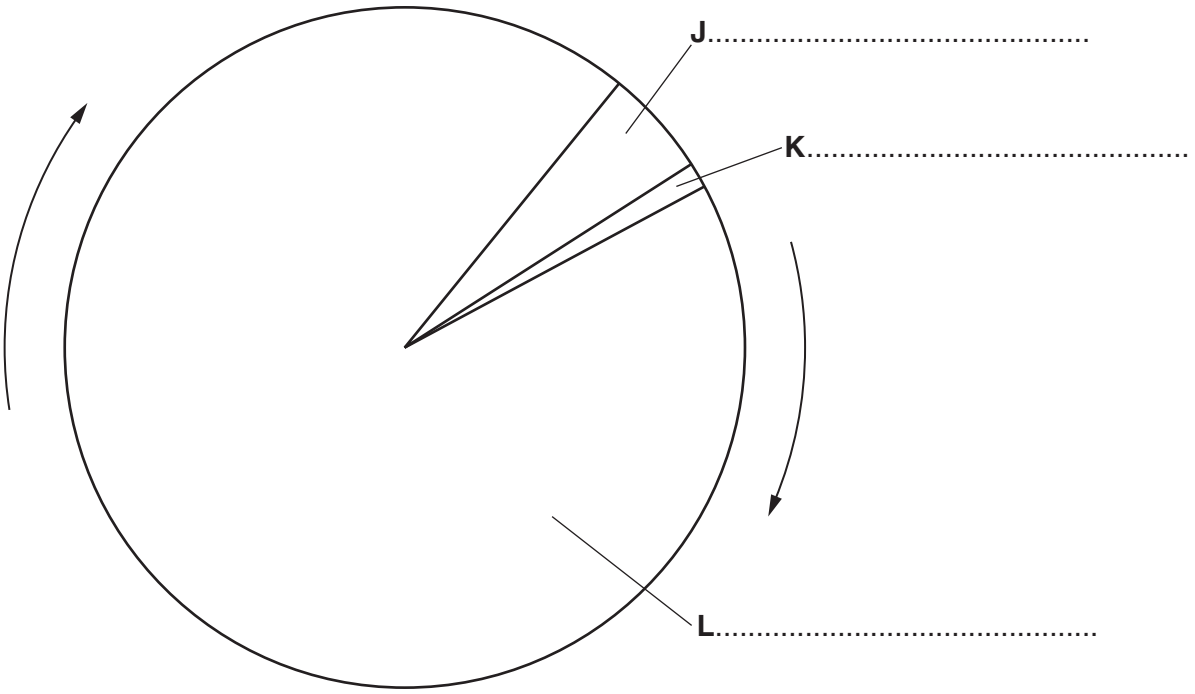
6 **(a)** Fig. 6.1 represents one complete cell cycle for a eukaryotic cell.

(i) Complete Fig. 6.1 by naming the stages represented by **J**, **K** and **L**.



[3]

Fig. 6.1

(ii) Name the stage in the cell cycle in which semi-conservative replication of DNA occurs.

.....[1]

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Answer **all** the questions.

1 A diagram of a chromosome from a dividing cell is shown in Fig. 1.1.

Fig. 1.1

(a) A dividing cell is at risk of losing genetic material each time DNA replication occurs.

On Fig. 1.1, add a label line and the letter **G** to show the location on the chromosome of an area that helps to prevent the loss of genes. [1]

(b) The chromosome shown in Fig. 1.1 consists of one long DNA molecule associated with histone proteins.

Name **one** stage of mitosis in which a chromosome would have the same general structure as the chromosome shown in Fig. 1.1.

..... [1]

(c) Name the stage in the mitotic cell cycle during which the cytoplasm and the cell divide to produce two genetically identical daughter cells.

..... [1]

(d) The control of the cell cycle can be affected by extracellular chemical messengers that bind to proteins and glycoproteins in the cell surface membrane. The overall mechanism is known as cell signalling.

State the term used to describe the proteins and glycoproteins that function in this way.

..... [1]

[Total: 4]

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3 Catalase is an enzyme that catalyses the breakdown of hydrogen peroxide, a toxic waste product of metabolism.

$$2H_2O_2 \xrightarrow{\text{catalase}} 2H_2O + O_2$$

(d) The cell has mechanisms to repair the damage to DNA caused by hydrogen peroxide. Errors in repair may cause a change to the structure of DNA.

Studies have investigated possible risks associated with foods and drinks that contain hydrogen peroxide. This is because the compound can be considered a mutagen. Mutagens cause mutations.

Explain why hydrogen peroxide can be considered a mutagen.

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..... [2]

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4 Meristematic tissue is found in the growing regions of plants, such as root tips.

(a) Fig. 4.1 summarises a cell cycle for a meristematic cell in the root tip. The two phases of this cell cycle are shown:

- interphase, which is divided into the G_1, S and G_2 stages
- cell division, which is divided into stages 1–5.

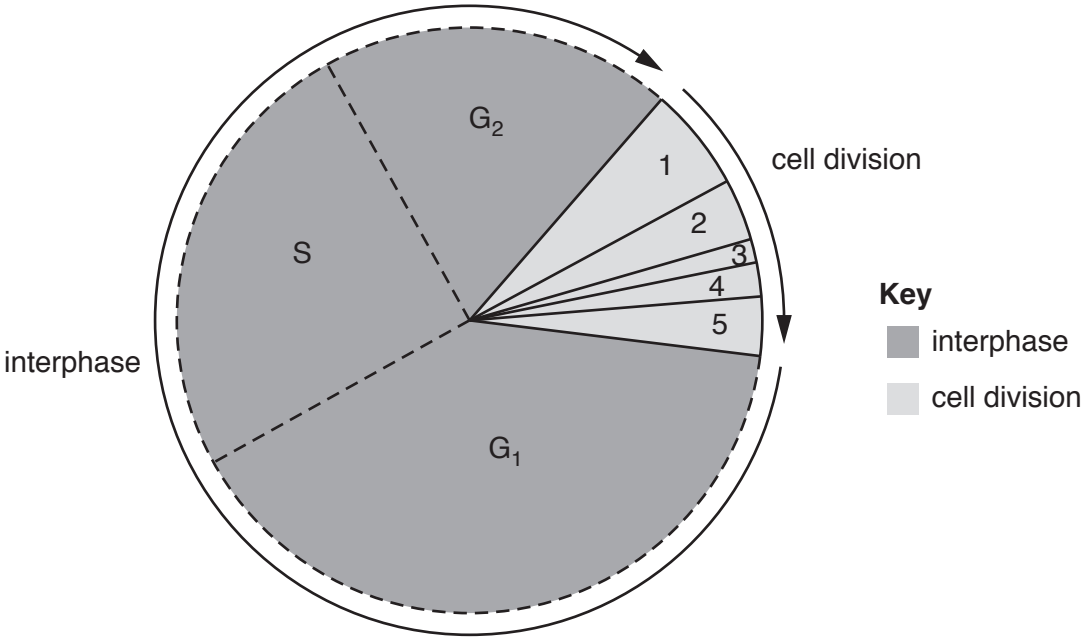

Fig. 4.1

(i) In Fig. 4.1, stage 2 is metaphase.

The stages shown in Fig. 4.1 are listed below. Draw a circle around the stage in the cell cycle that is cytokinesis **and** describe what happens in this stage in the root tip meristematic cell.

1 **2** **3** **4** **5** **G_1** **S** **G_2**

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.....[3]

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5 (d) Outline how mutations can cause healthy cells to become tumour cells.

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.....[3]

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1 Fig. 1.1 is a photomicrograph of plant cells showing stages in cell division.

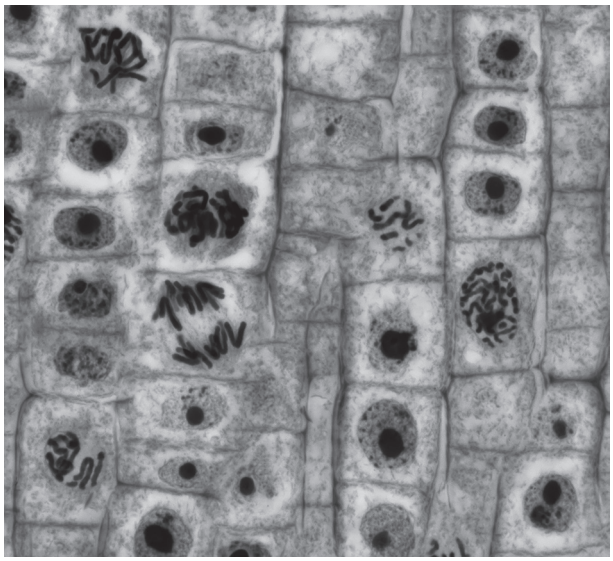

Fig. 1.1

(a) On Fig. 1.1, draw a circle around a cell in anaphase. [1]

(c) Mitosis is important in producing more cells for plant growth.

Describe **three other** ways in which mitosis is important in plants.

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..... [3]

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Answer **all** questions.

1 The root apical meristem is a region of undifferentiated cells in the root tips of plants. Mitosis occurs in this region.

(a) Fig. 1.1 is an image of the root tip of *Allium* as observed using a microscope with a low-power objective lens.

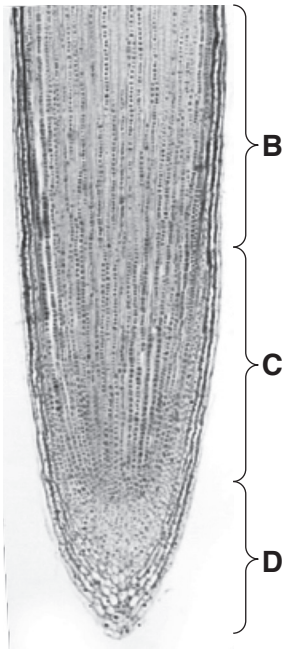

Fig. 1.1

State which region, **B**, **C**, or **D**, should be chosen in order to observe the highest proportion of cells in stages of mitosis.

.....[1]

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(b) (i) Draw a labelled diagram to show the structure of a chromosome at late prophase of mitosis.

[3]

(ii) Describe the behaviour of the nuclear envelope during mitosis.

.....

.....

.....

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.....[2]

[Total: 6]

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6 Extracellular growth factors are involved in the control of cell cycles in some mammalian cells. One of these growth factors is epidermal growth factor (EGF).

Fig. 6.1 shows the events that occur when EGF is present at the surfaces of two cells, **A** and **B**.

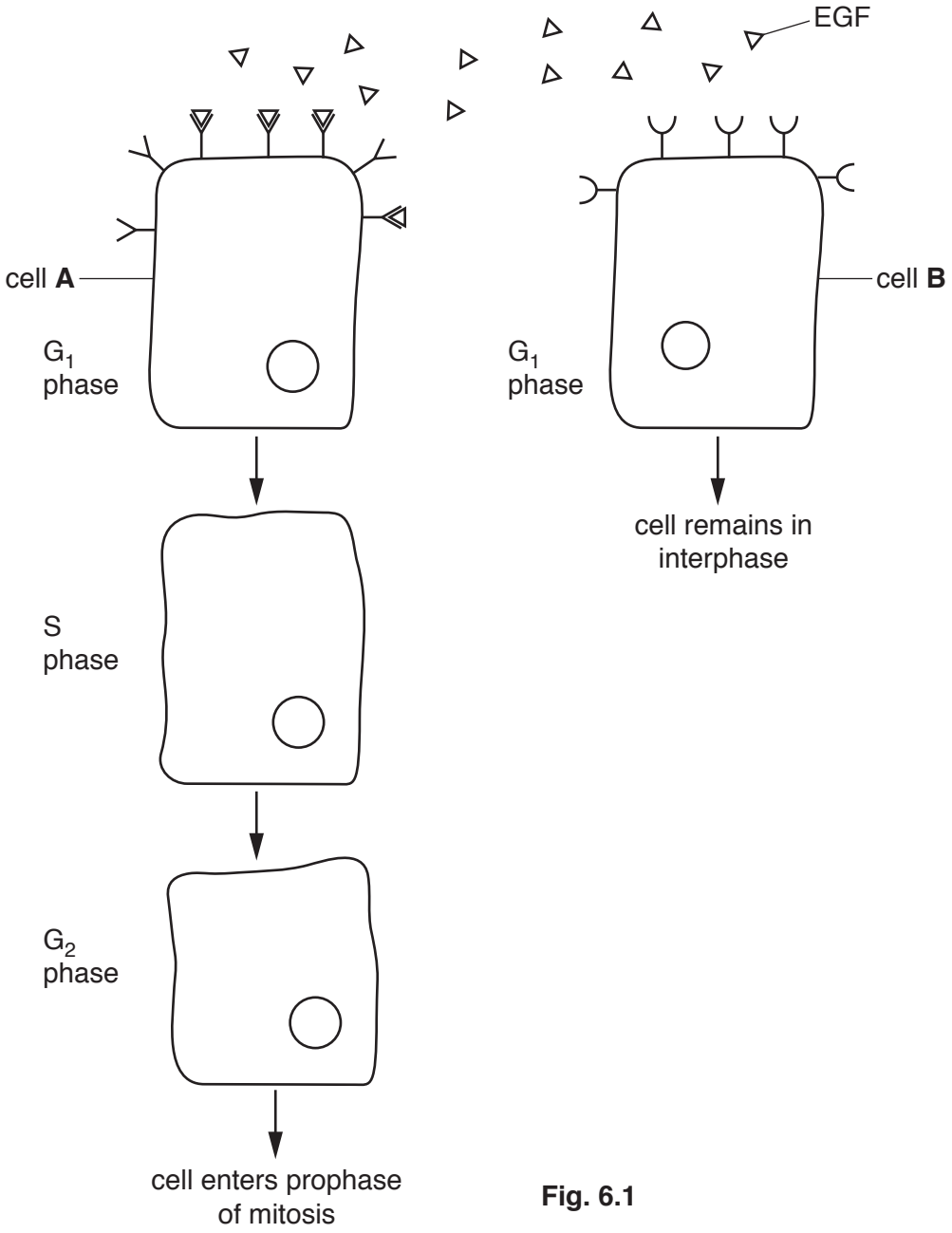

Fig. 6.1

(a) Explain why cell **A** in Fig. 6.1 responds to EGF, but cell **B** does not.

.....

.....

.....

.....

.....[2]

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(b) In the cell cycle, more mRNA is produced in the G_1 phase than during mitosis.

Suggest why this is so.

.....

.....

.....

.....[1]

(c) DNA is replicated during the S phase of the cell cycle. EGF is one of many factors that stimulate the change from the G_1 phase to the S phase.

State the substances used to synthesise DNA during the S phase.

.....

.....

.....

.....

.....[3]

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(d) Fig. 6.2 is a drawing of chromosome 1 from rice, *Oryza sativa*, during metaphase of mitosis.

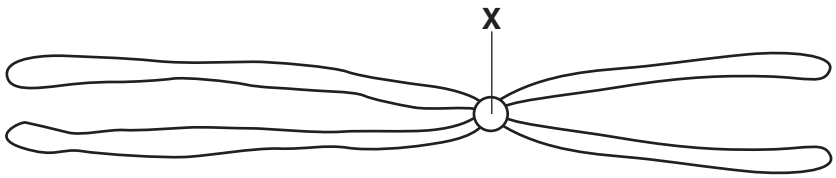


Fig. 6.2

(i) State the name and function of the region of the chromosome labelled **X**.

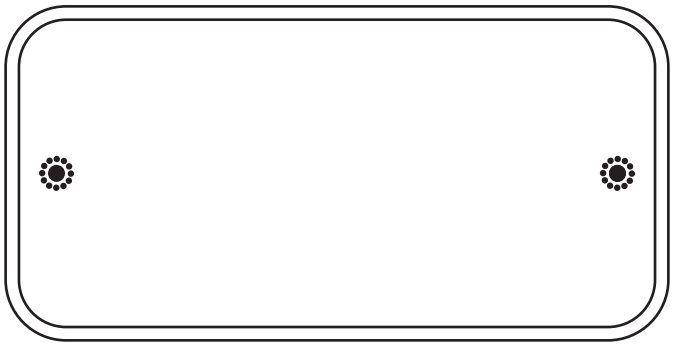
name .....

function .....

.....

.....[2]

(ii) In the outline of the cell below, draw the chromosome from Fig. 6.2 as it would appear in anaphase of mitosis.



[2]

[Total: 10]

6 (b) Fig. 6.2 is a photomicrograph of root tip cells at different stages in the cell cycle. A cell in interphase is labelled.

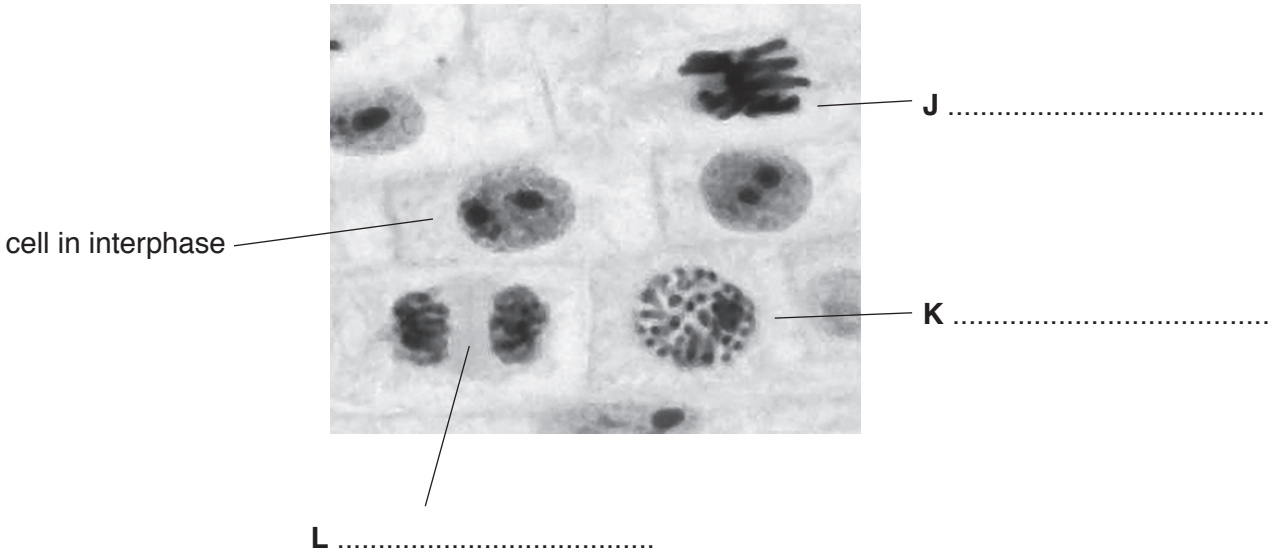


Fig. 6.2

(i) Name the stage of mitosis shown in each of cells **J**, **K** and **L** in Fig. 6.2.

Write your answer in the space next to each letter on Fig. 6.2. [3]

(ii) Explain how it is possible to deduce that the labelled cell in interphase shown in Fig. 6.2 is in late, rather than early, interphase.

.....

.....

..... [1]

(iii) Describe the stage of mitosis shown in cell **J**.

.....

.....

.....

..... [2]

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4 Fig. 4.1 is a photomicrograph showing some cells in interphase and some cells in stages of mitosis.

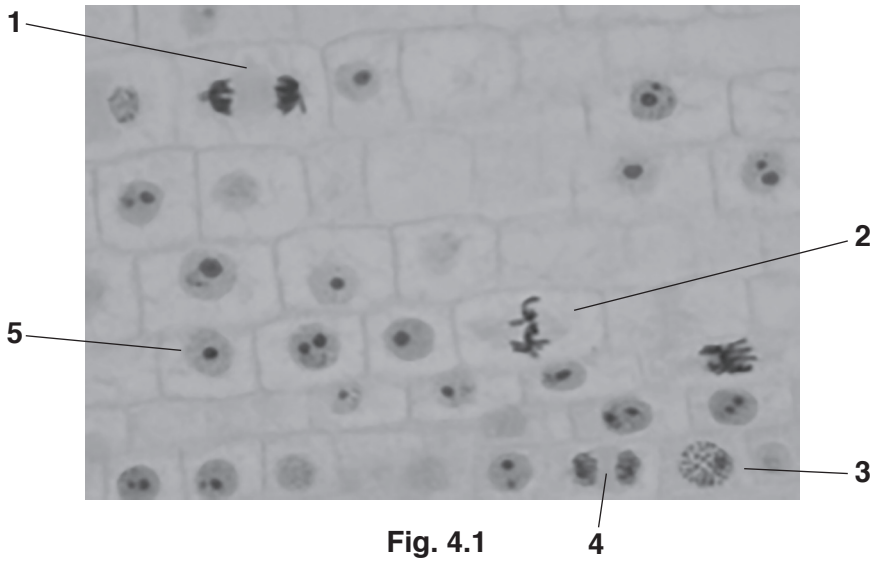

Fig. 4.1

(a) Choose from the cells labelled **1** to **5** in Fig. 4.1 to identify the cell in which:

- the nuclear envelope is reassembling .....
- the spindle begins to form .....
- there is a high rate of transcription and translation .....

[3]

(b) Cell **2** is in a stage of mitosis that occurs before the stage of mitosis shown in cell **1**.

Outline the changes that would occur from the stage of mitosis shown in cell **2** to the stage shown in cell **1**.

.....

.....

.....

.....

.....

.....[2]

(c) Suggest why some cells in Fig. 4.1 appear empty, with no nucleus or chromosomes.

.....

.....

.....[1]

[Total: 6]

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1 Fig. 1.1 is a photomicrograph of root tip meristem. Different stages of the cell cycle are visible. Some cells are in the same stage of the cell cycle and some are in the same stage of mitosis.

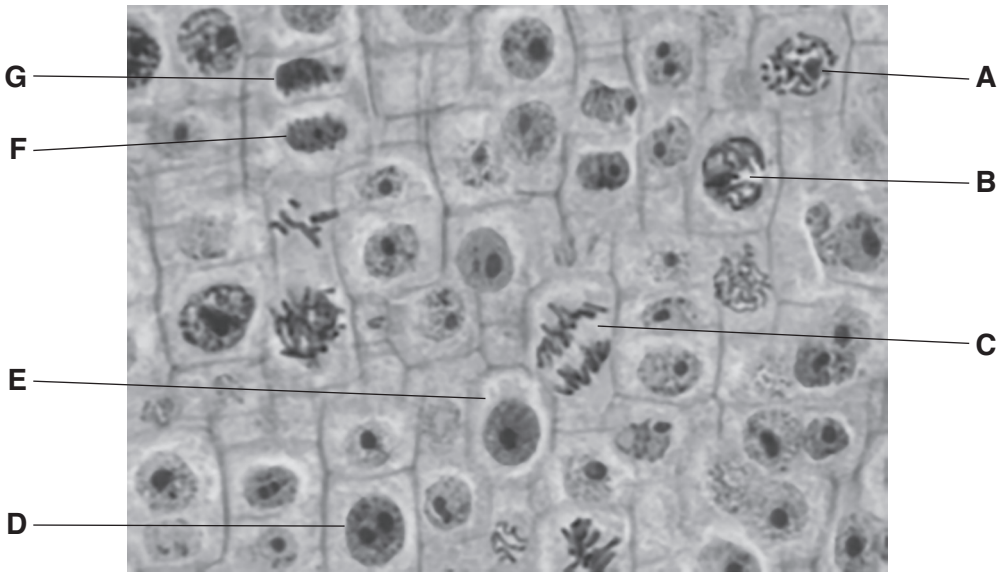

Fig. 1.1

(a) Cell **D** and cell **E** are in the same stage of the cell cycle.

State the difference between the nucleus of cell **D** and cell **E**.

.....

.....[1]

(b) Name the stage of mitosis occurring in each of cells **A**, **B** and **C**.

cell **A** .....

cell **B** .....

cell **C** .....[3]

(c) Cells **F** and **G** are newly formed cells. Cytokinesis has occurred with the formation of a cell plate.

Describe the events that have occurred in the stage of mitosis immediately **before** cytokinesis.

.....

.....

.....

.....[2]

[Total: 6]

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4 **(b)** Some epithelial cells in the kidney release the protein vascular endothelial growth factor (VEGF). This protein is a cell signalling molecule that stimulates cell division in endothelial cells in blood vessels.

(i) State what occurs during interphase to prepare a cell for division.

.....

.....

.....

.....

..... [2]

(ii) Explain how a cell signalling molecule, such as VEGF, can lead to a response in a cell.

.....

.....

.....

..... [2]

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3 The response of the human body to tissue damage depends on the types of tissues involved. Epithelial tissue, liver tissue and cardiac muscle tissue each respond differently to damage.

- Epithelial tissue of the gas exchange system contains stem cells.
- Liver tissue contains cells in a non-dividing state that can enter a cell cycle when stimulated.
- Cardiac muscle tissue contains cells that cannot divide at all. Damage is permanent and is associated with scar tissue formation.

(a) Explain the importance of mitosis in the repair of damaged tissue.

.....

.....

.....

.....

..... [2]

(b) Explain why stem cells are important in tissue repair.

.....

.....

.....

.....

..... [2]

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6 **(a)** As part of a study of the mitotic cell cycle, a student made stained sections of a root tip of onion, *Allium cepa*, and observed them with a light microscope.

The student made drawings of six of the cells, **A** to **F**, using the high power of the microscope, as shown in Fig. 6.1.

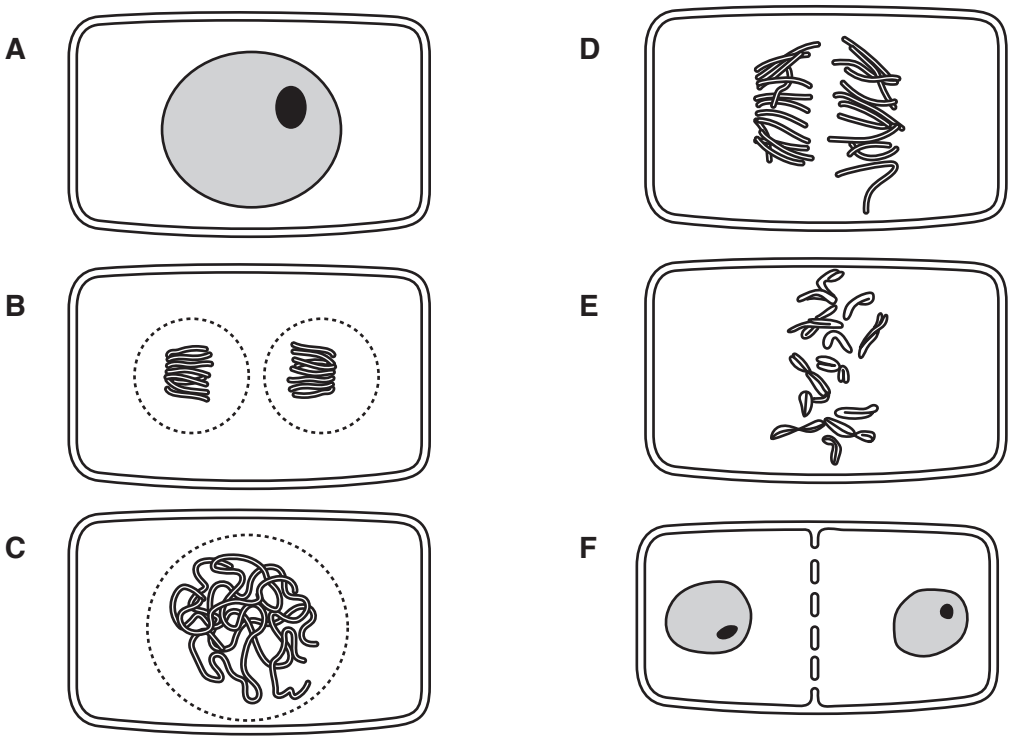

Fig. 6.1

(i) Complete Table 6.1 to show the sequence of stages in the mitotic cell cycle, using the letters, **A** to **F**, as shown in Fig. 6.1.

Table 6.1

sequence of stages	cell
1	**A**
2	
3	
4	
5	
6	

[1]

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(ii) Table 6.2 shows some events that occur during the mitotic cell cycle in *A. cepa*.

Complete Table 6.2 by naming the stage of the cell cycle when each event occurs.

Table 6.2

event in the cell cycle	name of the stage in the cell cycle
DNA replication	
division of centromeres	
condensation of chromatin	
contraction of spindle fibres	
organisation of chromosomes at the equator	metaphase

[4]

(b) Explain the importance of mitosis in the immune response.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 8]

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6 Plant and animal cells carry out mitosis to form two genetically identical cells from one original cell.

(a) State **other** reasons why mitosis is important in **both** plants and animals.

.....

.....

.....

.....

..... [2]

(b) Plant cells require microtubules to form structures that are needed for mitosis.

Name **one** of these structures.

..... [1]

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4 Meristematic tissue is found in the growing regions of plants, such as shoot tips. Meristematic cells have a similar role to stem cells in animals.

Fig. 4.1 shows some of the stages in the formation of a mature phloem sieve tube element and companion cells from a meristematic cell.

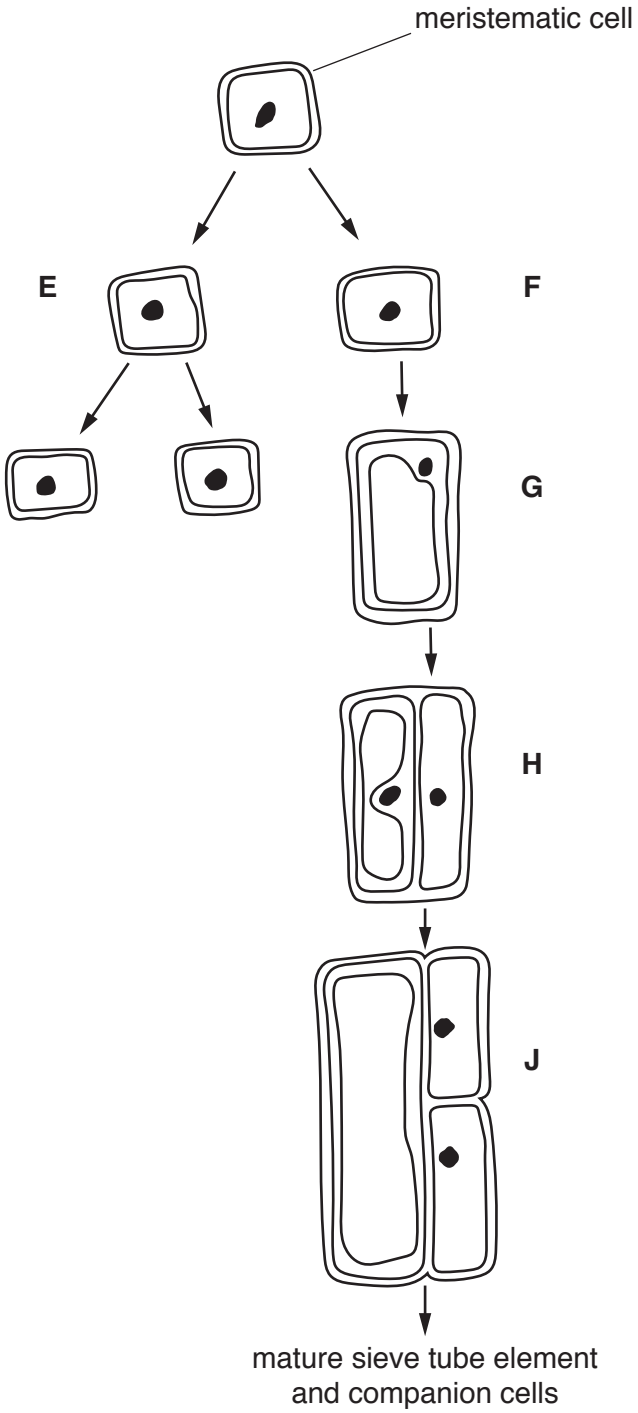

Fig. 4.1

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(a) Cells **E** and **F** in Fig. 4.1 are daughter cells produced when the meristematic cell divides in the shoot tip.

Explain why it is important that one of the daughter cells (cell **E**) is a meristematic cell.

.....

.....

..... [1]

(b) Complete Table 4.1 to describe the changes that are shown in Fig. 4.1 between stages:

- **F** and **G**
- **G** and **H**
- **H** and **J**.

Table 4.1

stages	description
F and **G**	
G and **H**	
H and **J**	

9700/21/O/N/19

6(c) Fig. 6.1 is a scanning electron micrograph of a lung cancer cell in a stage of the cell cycle.

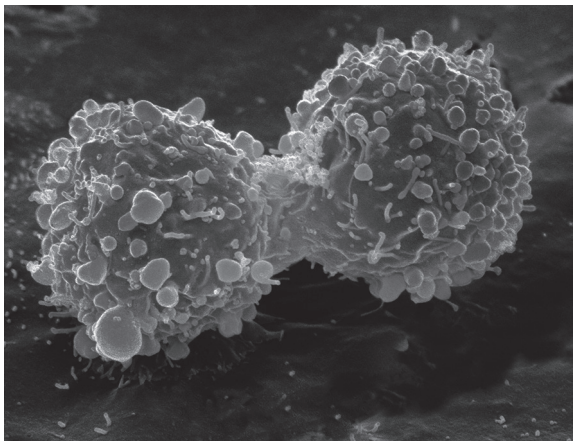

Fig. 6.1

(i) Name the stage of the cell cycle occurring in Fig. 6.1.

..... [1]

2 Meristematic tissue is found in the growing region of plants, such as root tips.

Fig. 2.1 shows a section through the meristematic region of a root tip of onion, *Allium cepa*.

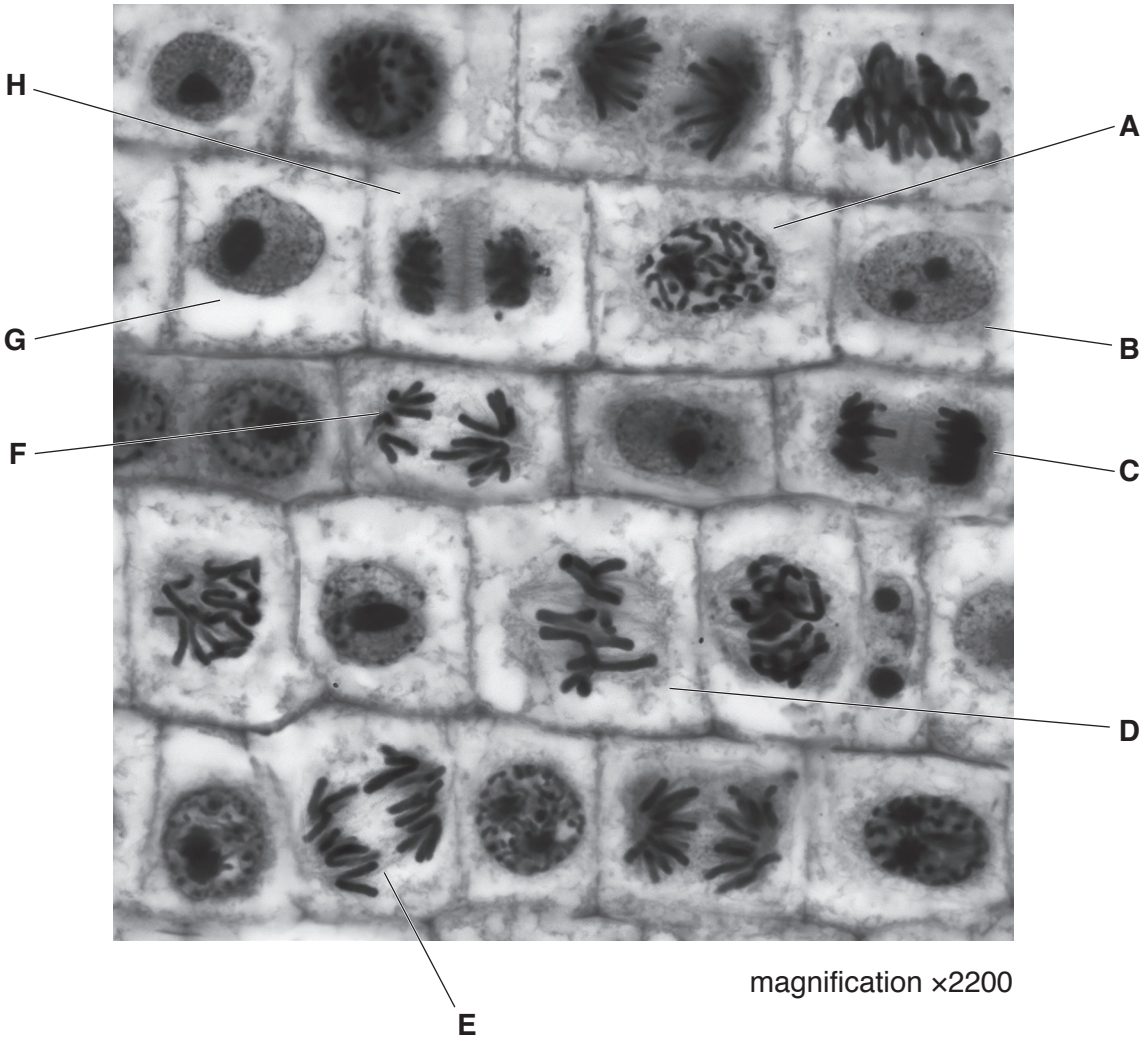

Fig. 2.1

Table 2.1 shows the numbers of cells in different stages of the cell cycle that were observed in sections of the meristematic regions of root tips of *A. cepa*.

Table 2.1

stage of cell cycle	one example of cell from Fig. 2.1	number of cells counted in each stage			
		replicate 1	replicate 2	replicate 3	mean
interphase		4686	4709	4808	4734
prophase		148	159	155	154
metaphase		38	47	40	42
anaphase		25	33	28	29
telophase		38	47	39	41
				total	5000

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(a) Complete Table 2.1 by using the letters **A** to **H** from Fig. 2.1 to identify **one** cell in each stage of the cell cycle. [3]

(b) The total length of time taken for meristematic cells of *A. cepa* to complete one cell cycle at 25 °C is 12 hours.

Using sections similar to the one in Fig. 2.1, the length of time spent in each stage of the cell cycle can be estimated. To obtain the estimate, the percentage of cells in that stage is calculated.

Using the data in Table 2.1, calculate:

- the percentage of cells in anaphase
- the mean length of time in **minutes** for anaphase.

Show your working.

percentage of cells in anaphase = ... %

mean length of time in anaphase = ... min
[2]

(c) State **one** event that occurs during cytokinesis in the cell cycle of plant cells, such as those shown in Fig. 2.1.

.....

..... [1]

[Total: 6]

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4 (b) The mitotic cell cycle of the stem cells present in the gas exchange system is carefully controlled. During interphase of the mitotic cell cycle, cells grow by increasing in size.

Complete Table 4.1 by:

- listing, in order, the three phases that occur during interphase
- stating **one** process, other than growth and respiration, that occurs in each of these three phases to help prepare the cell for mitosis.

Table 4.1

phase	process occurring during phase

[4]

2 Fig. 2.1 shows some stages of the cell cycle in the meristematic tissue in the root tip of a plant. Three of these stages, **P**, **Q** and **R**, are identified in Table 2.1.

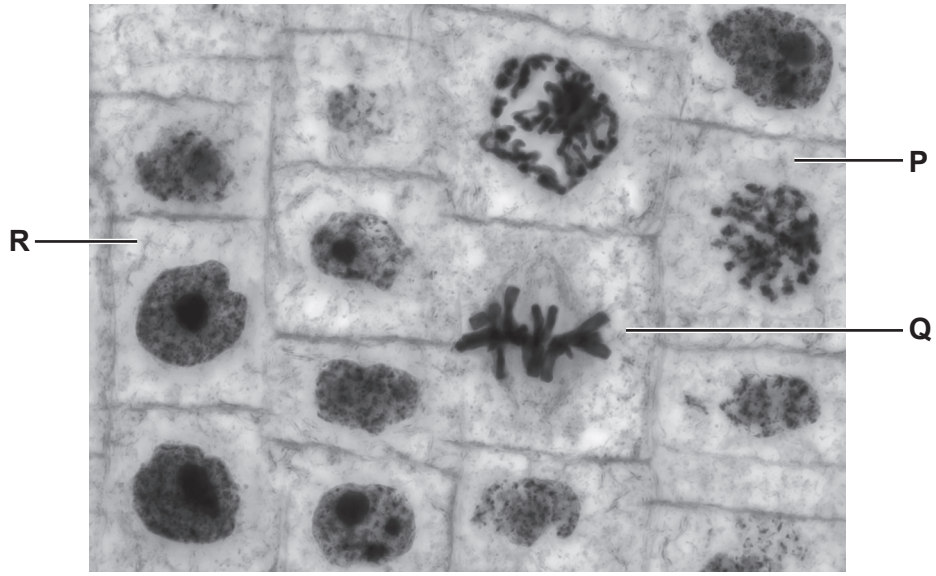

Fig. 2.1

(a) Complete Table 2.1 by stating **one** feature, **visible in Fig. 2.1**, that is used to identify each stage.

Table 2.1

cell	stage of cell cycle	reason
P	prophase of mitosis	
Q	metaphase of mitosis	
R	interphase	

[3]

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(b) (i) Draw a labelled diagram to show **one** chromosome at metaphase of mitosis.

On the chromosome you have drawn add labels to show:

- the position of a telomere
- a chromatid
- the centromere.

[4]

(ii) State the type of protein that is associated with DNA in chromosomes.

..... [1]

(iii) Describe how the spindle is involved during the process of mitosis.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 11]

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6 The mitotic cell cycle in dividing cells is very carefully controlled.

(a) Complete Table 6.1 to show the correct order of stages in the mitotic cell cycle.

Some of the stages have been completed for you.

Table 6.1

stage of cell cycle	
G_1 phase	
.....	.....
.....	
.....	mitosis
.....	
.....	
telophase	
cytokinesis	

[3]

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At various points during the mitotic cell cycle, checks are made. A cell goes through cell death (apoptosis) if errors occur that cannot be repaired. This makes sure that the daughter cells produced are genetically identical to each other and to the original cell.

Drugs have been developed that can inhibit the mitotic cell cycle and cause the cell to carry out apoptosis. These drugs are used in the treatment of cancer.

(b) Vincristine and 5-fluorouracil are chemical compounds that act as cell cycle inhibitors and can lead to apoptosis.

- Vincristine binds to spindle microtubules and prevents the spindle from carrying out its function.
- 5-fluorouracil prevents the synthesis of thymine nucleotides.

Complete Table 6.2 to show which event in the cell cycle will occur when Vincristine or 5-fluorouracil are added to healthy dividing cells at the start of the interphase stage of the cell cycle.

Place a tick (✓) if the event will occur or a cross (✗) if the event will **not** occur.

All boxes in the table should be completed.

Table 6.2

event in cell cycle / compound	S-phase completes	cell enters prophase of mitosis	chromosomes line up at spindle equator	sister chromatids move towards opposite poles
Vincristine				
5-fluorouracil				

[2]

5 Blood cells are formed from tissue stem cells in the bone marrow. These bone marrow stem cells go through a number of mitotic cell cycles to form the fully functioning blood cell.

Fig. 5.1 shows the three main stages of the cell cycle.

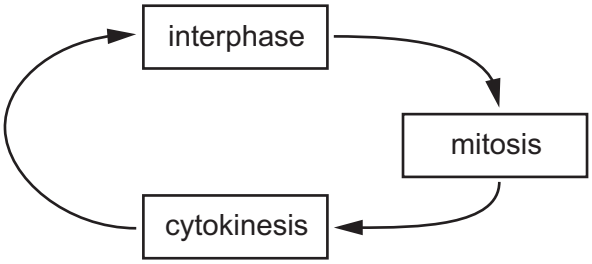

Fig. 5.1

The activity of genes changes during the mitotic cell cycle.

When genes are being expressed, the cell produces many messenger RNA (mRNA) molecules and ATP molecules.

(a) Explain what is meant by a gene.

.....

.....

.....

..... [2]

(b) Name the main stage of the cell cycle in Fig. 5.1 during which most mRNA and ATP is formed.

..... [1]

1 **(a)** Fig. 1.1 is a diagram of a human chromosome at a stage in mitosis.

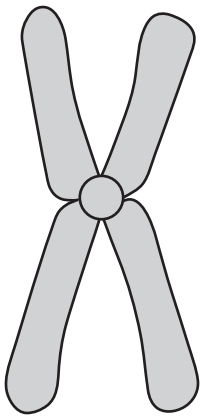

Fig. 1.1

(i) The paragraph describes the structure of the chromosome shown in Fig. 1.1.

Complete the paragraph using the most appropriate term in each space provided.

The chromosome shown in Fig. 1.1 has two genetically identical ..... joined at a ..... . The chromosome is composed of two DNA molecules, each wrapped around proteins known as ..... proteins.

[3]

(ii) State **one** stage during mitosis when the chromosome would appear as shown in Fig. 1.1.

..... [1]

(iii) Suggest the role of ATP in the process of mitosis.

.....

.....

.....

.....

..... [2]

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(b) Prokaryotes divide by a process known as binary fission.

Fig. 1.2 shows some of the stages in binary fission.

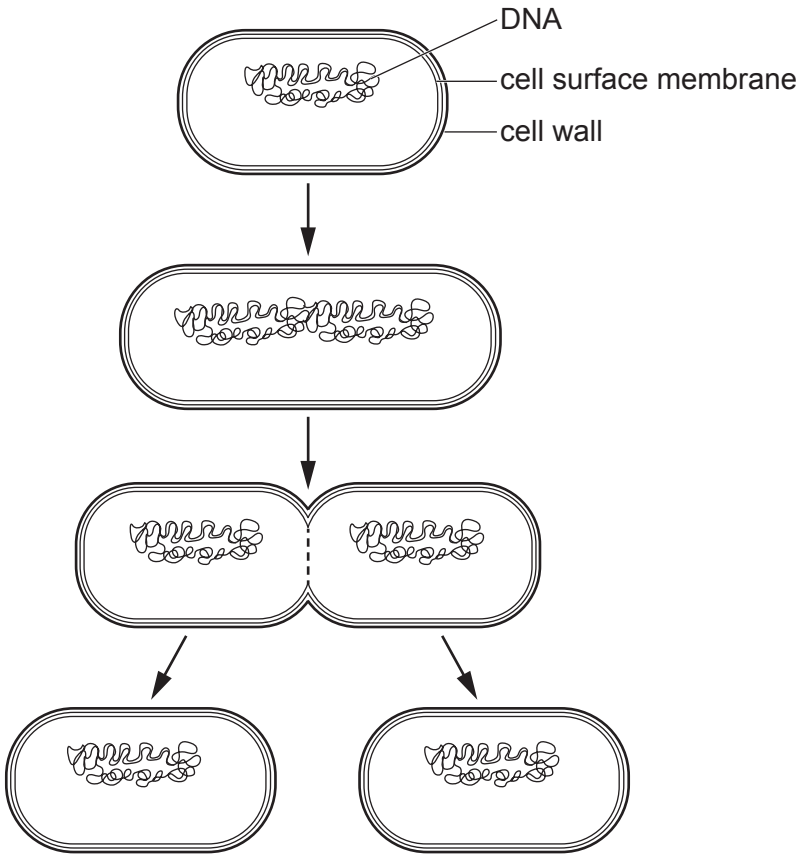

Fig. 1.2

With reference to Fig. 1.2, identify **two** events that occur during binary fission that do **not** occur during mitosis in human cells.

.....

.....

.....

.....

..... [2]

[Total: 8]

4 In the immune system, a plasma cell develops from an activated B-lymphocyte. Mature plasma cells synthesise and secrete antibody molecules.

(a) Fig. 4.1 is a diagram of a transmission electron micrograph of a plasma cell.

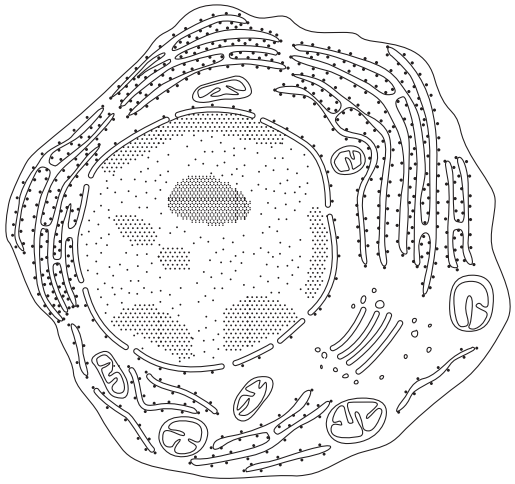

Fig. 4.1

The plasma cell can be seen in greater detail using an electron microscope compared with using a light microscope.

(i) Describe the **extra** detail of the nucleus that can be seen using an electron microscope.

.....

.....

.....

BASED UPON TOPIC 1

.....

.....

.....

..... [3]

(ii) Explain why cell structures, such as ribosomes and the rough and smooth endoplasmic reticulum, cannot be seen using a light microscope.

.....

.....

BASED UPON TOPIC 1

.....

.....

..... [2]

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(b) The transition from the activated B-lymphocyte to the fully mature plasma cell requires a number of mitotic cell cycles to occur. This process, which is known as clonal expansion, results in a large number of genetically identical plasma cells.

Fig. 4.2 describes events, **A** to **F**, that occur during the mitotic cell cycle of the B-lymphocyte.

A centrioles replicate

B DNA polymerase catalyses the formation of phosphodiester bonds

C condensation of chromosomes

D nuclear envelope reassembles around each set of daughter chromosomes

E centromeres move towards poles

F chromosomes line up at spindle equator

Fig. 4.2

Table 4.1 lists the stages occurring during one cell cycle of the B-lymphocyte. These stages are not in the correct order.

Table 4.1

stage of cell cycle	**correct letter from Fig. 4.2**
G_2 phase	
metaphase	**F**
cytokinesis	
prophase	
S phase	
anaphase	
G_1 phase	
telophase	

Complete Table 4.1 by writing the letter of the event described in Fig. 4.2 that correctly matches the stage of the cell cycle listed.

Leave a **blank space** if there is **no** matching description for the stage in the list. Use each letter **once** only.

One of the letters in Table 4.1 has already been added for you.

[5]

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3 Fig. 3.1 shows the nematode worm, *Caenorhabditis elegans*.

Fig. 3.1 magnification ×250

Stem cells of *C. elegans* have been studied.

Fig. 3.2 shows the change in mass of DNA per nucleus in a stem cell during one cell cycle.

$1\,pg = 1 \times 10^{-12}\,g$

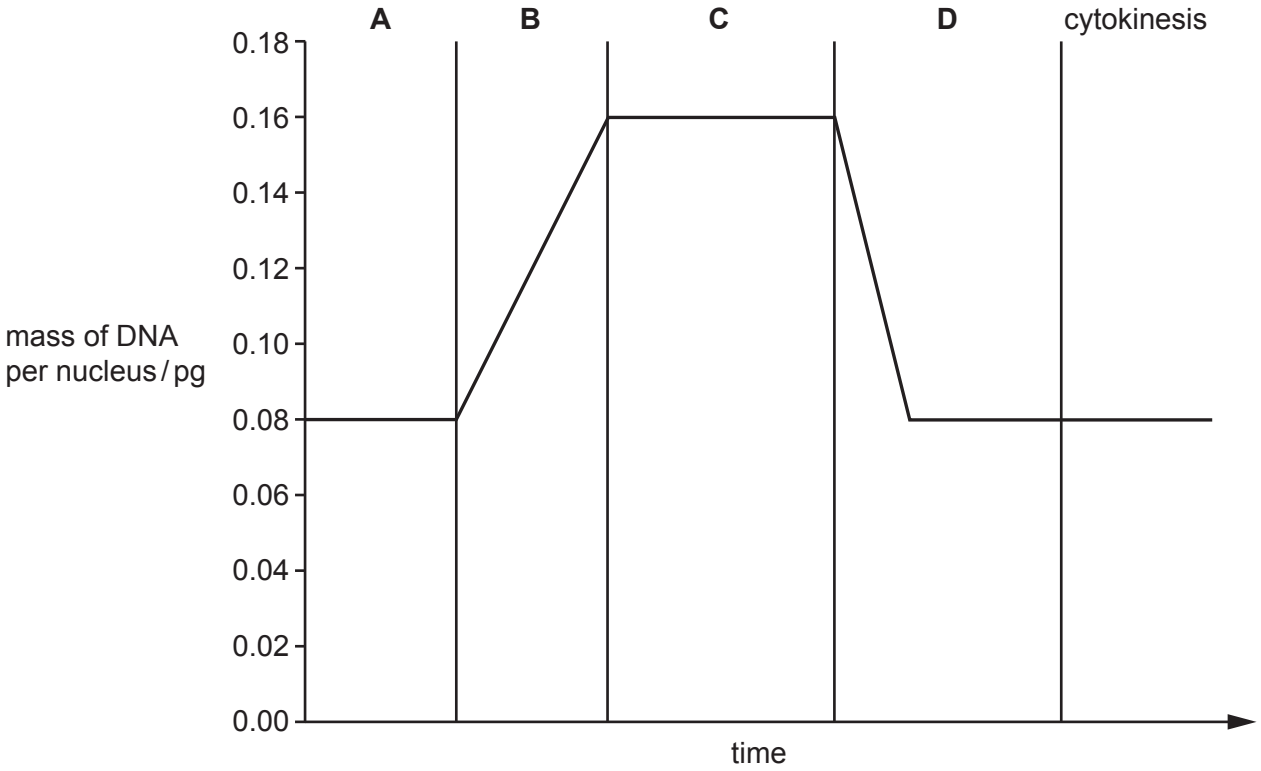

Fig. 3.2

(a) (i) State the phases of interphase shown by **A** and **B** in Fig. 3.2.

A .....

B .....

[2]

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(ii) State the stage of mitosis shown by **D** in Fig. 3.2.

..... [1]

(iii) Outline what happens in a cell in preparation for cytokinesis.

.....

.....

.....

.....

.....

..... [2]

(iv) A stem cell of a female *C. elegans* has 12 chromosomes.

Complete Table 3.1 to show the number of nuclei within the stem cell in stages **A**, **B** and **D** of the cell cycle shown in Fig. 3.2 **and** the number of chromosomes in each nucleus during these stages.

Table 3.1

	stage of the cell cycle		
	A	**B**	**D**
number of nuclei within the stem cell			
number of chromosomes in each nucleus			

[2]

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5 Each meristem cell in a leaf bud is able to grow and divide by mitosis to produce two daughter cells that are genetically identical to each other and to the original dividing cell.

(a) Fig. 5.1 lists the stages in the mitotic cell cycle of a meristem cell.

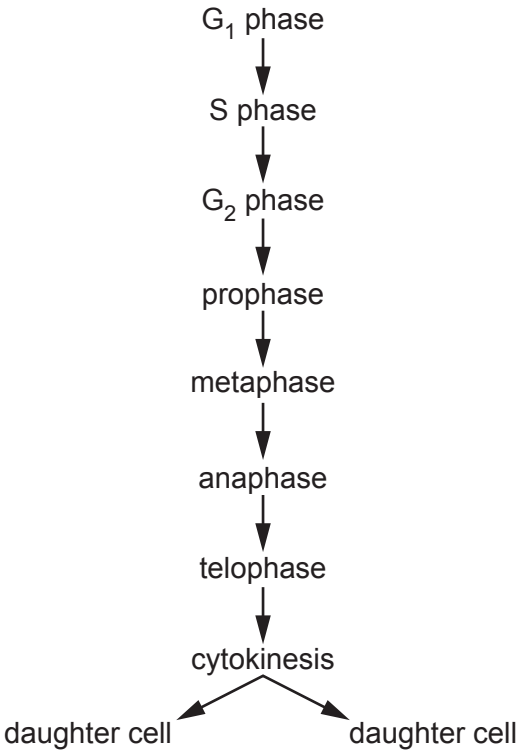

Fig. 5.1

(i) Outline **and** explain the events occurring during S phase, metaphase and anaphase of the mitotic cell cycle that are important in the production of genetically identical daughter cells.

S phase .....

.....

.....

.....

metaphase .....

.....

.....

.....

anaphase .....

.....

.....

.....

[4]

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9700/22/F/M/21

(ii) Immediately after cytokinesis, daughter cells are **not** identical even though they are genetically identical.

Suggest a reason why daughter cells are **not** identical immediately after cytokinesis.

.....

.....

..... [1]

9700/22/M/J/21

1 **(a)** Fig. 1.1 is a photomicrograph of a region of eukaryotic tissue. Some of the cells are in stages of mitosis.

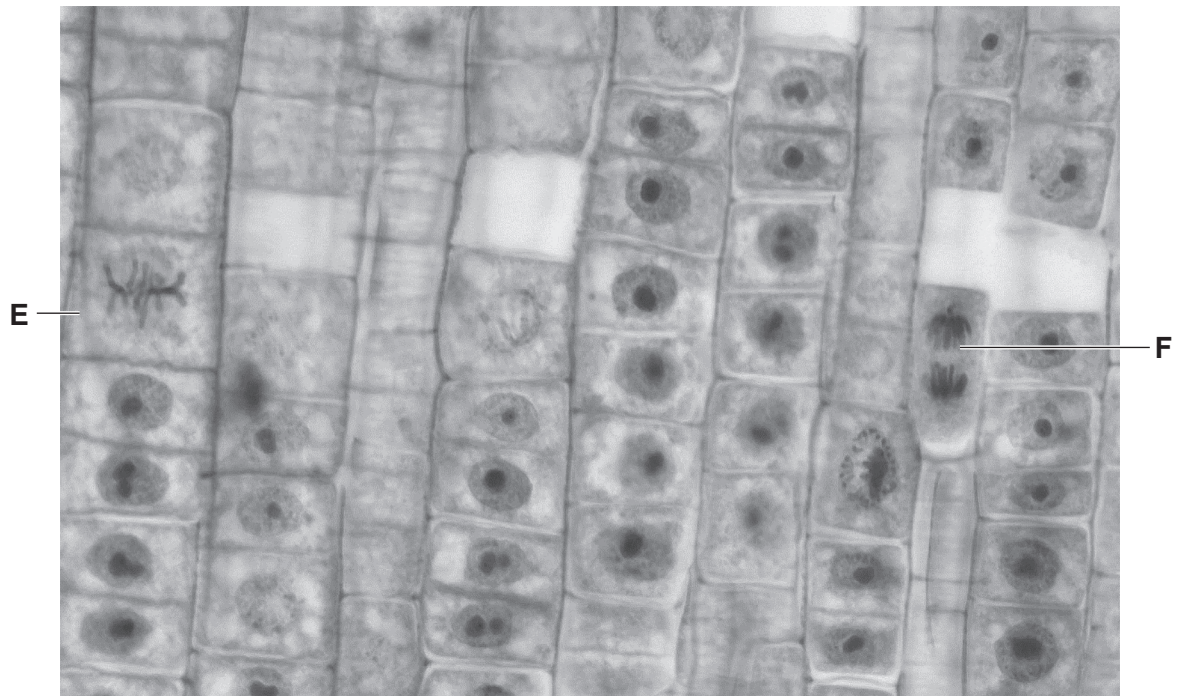

Fig. 1.1

(i) Identify which stage of mitosis is shown in cell **E** and in cell **F** in Fig. 1.1.

E .....

F ..... [2]

(ii) Microtubules are present within the cells that are in stages of mitosis, but these are not visible in Fig. 1.1.

State the function of microtubules in mitosis.

.....

.....

..... [1]

6 The best time to obtain a clear image of chromosomes during a mitotic cell cycle is during the metaphase stage.

Fig. 6.1 is a scanning electron micrograph of a group of human chromosomes at metaphase.

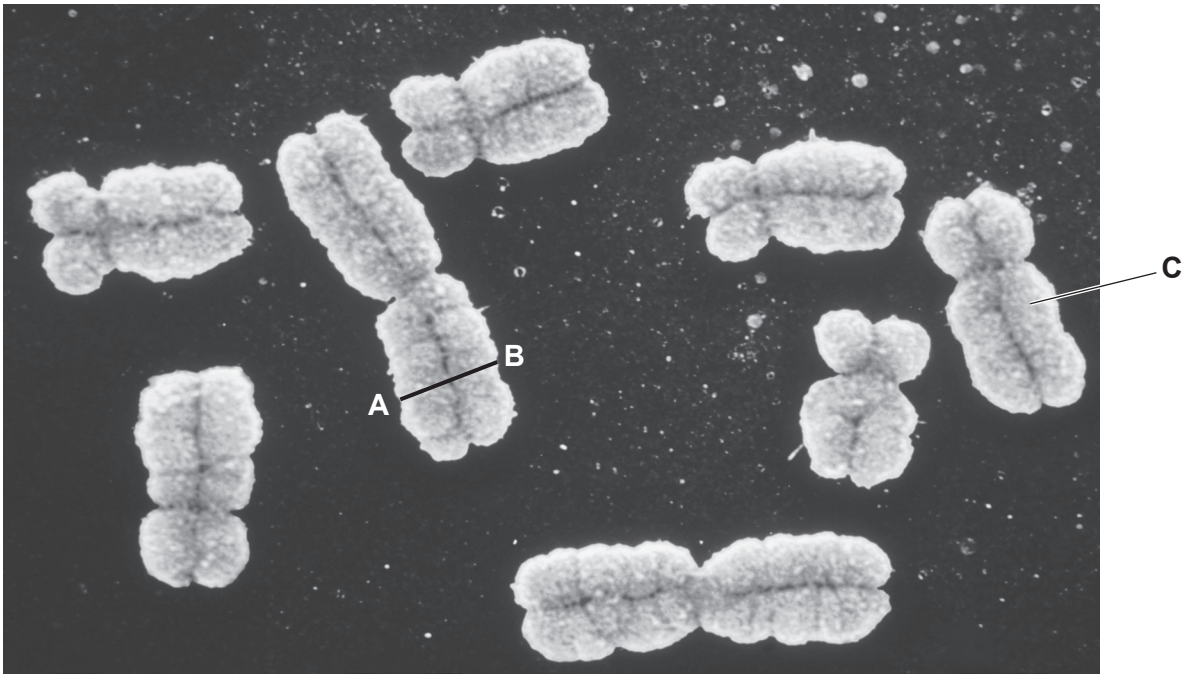

Fig. 6.1

(b) Draw chromosome **C** in Fig. 6.1 in the space provided.

Label your drawing to show the structure of the chromosome.

[4]

(c) Suggest why the metaphase stage is the best time during a mitotic cell cycle to obtain a clear image of chromosomes.

.....

.....

..... [1]

(d) Name the stage of mitosis that immediately follows metaphase.

..... [1]

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4 **(a)** Fig. 4.1 is a drawing made by a student of a plant cell, showing one of the stages of mitosis.

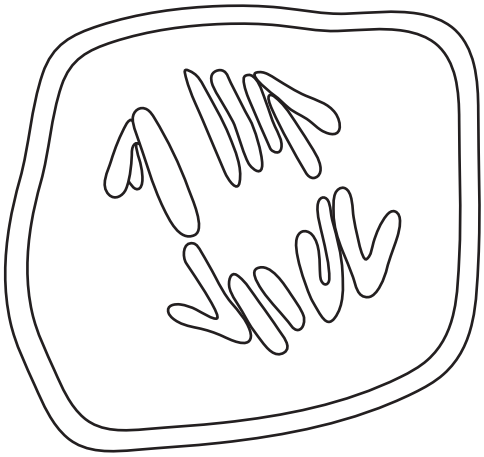

Fig. 4.1

(i) Describe the role of the spindle during this stage of mitosis.

.....

.....

.....

..... [2]

(ii) The chromosomes are composed of DNA.

Describe the structure of a monomer of a DNA molecule.

.....

.....

.....

..... [2]

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(b) Telomeres are located at the ends of each chromosome.

Telomeres progressively shorten each time a healthy human cell divides, until the cell is no longer able to divide.

Stem cells have an enzyme called telomerase that prevents the telomeres shortening during the cell cycle.

(i) Suggest why telomerase activity is important in stem cells.

.....

.....

.....

..... [2]

(ii) Suggest why tumour cells produce high concentrations of telomerase.

.....

.....

..... [1]

9700/22/O/N/21

1(d) Fig. 1.2 shows plant cells in a root tip where cell division by mitosis is taking place.

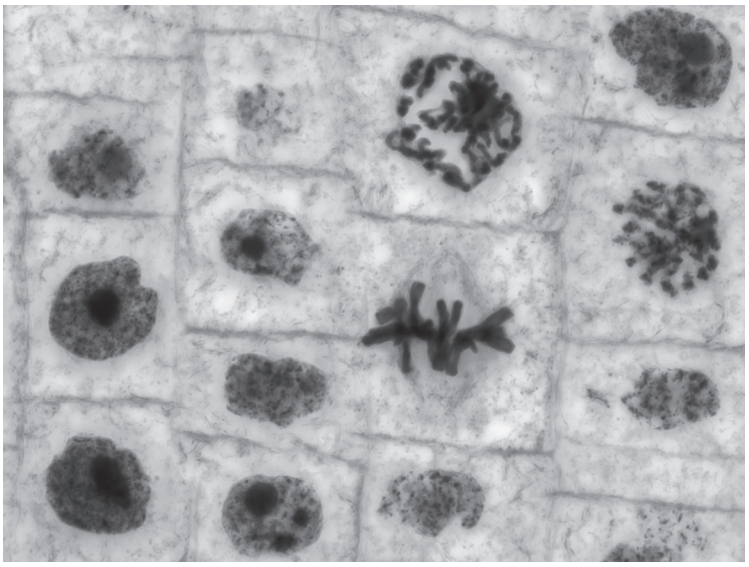

Fig. 1.2

Identify **two** cells in Fig. 1.2 that are in different stages of mitosis.

Draw a label line to each cell and add the name of the stage of **mitosis** that is shown by the cell. [2]

2 **(a)** Fig. 2.1 shows a cell at one of the main stages of mitosis in the mitotic cell cycle.

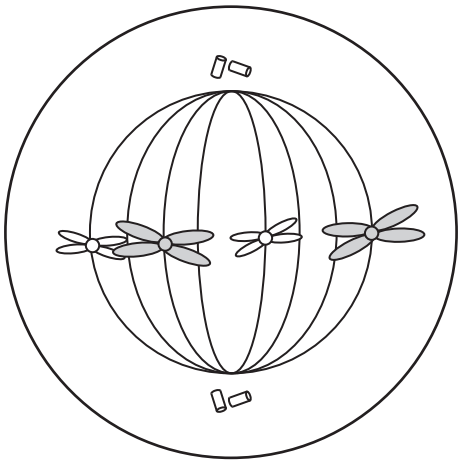

Fig. 2.1

(i) Name the stage of mitosis shown in Fig. 2.1.

..... [1]

(ii) Fig. 2.2 shows the cell in Fig. 2.1 at the start of cytokinesis.

Complete Fig. 2.2 to show the daughter chromosomes in each nucleus.

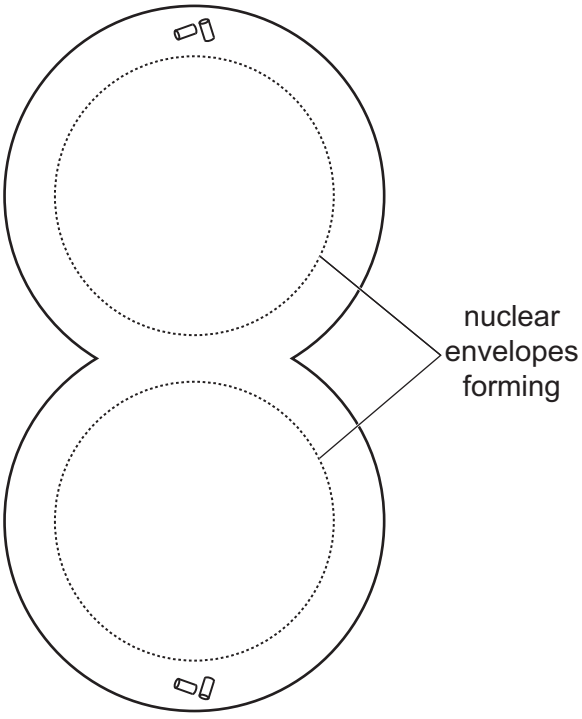

Fig. 2.2

[2]

(b) State the role of telomeres during DNA replication.

.....

.....

..... [1]

(c) Multiple myeloma is a type of cancer in the bone marrow where some of the stem cells start to produce abnormal blood cells.

- One treatment is to collect stem cells from the bone marrow of the person with multiple myeloma. Healthy stem cells are isolated and grown in the laboratory.
- Radiation is then used to destroy all stem cells and cancerous cells in the bone marrow.
- Finally, large numbers of the healthy stem cells grown in the laboratory are returned to the bone marrow.

Suggest the role of stem cells in this treatment of multiple myeloma.

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.....

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..... [3]

[Total: 7]

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1(d) Stem cells are also located in the wall of the small intestine. These cells divide by mitosis continuously.

Suggest **and** explain the importance of mitosis by stem cells in the small intestine.

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..... [4]

6 **(a)** Fig. 6.1 is a photomicrograph of plant cells in stages of the mitotic cell cycle.

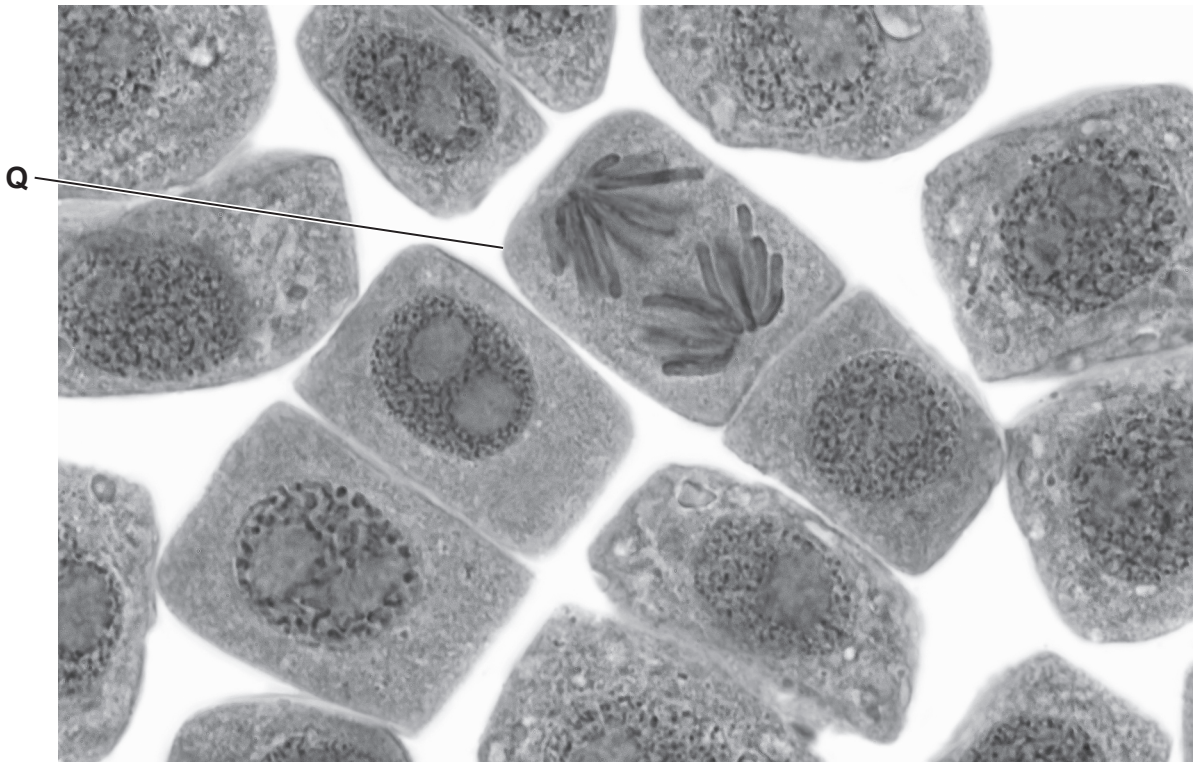

Fig. 6.1

(i) Name the stage of mitosis shown in cell **Q**.

..... [1]

(ii) Outline the roles of mitosis in a healthy plant.

.....

.....

.....

..... [2]

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(b) Uncontrolled mitosis can cause cancer in humans.
Paclitaxel is a drug used in the treatment of some forms of cancer.

Researchers investigated the effect of Paclitaxel on the mitotic cell cycle of cancer cells.

- The cancer cells were grown for two days and then divided into groups.
- Each group was treated with a different concentration of Paclitaxel.

After 28 hours (one cell cycle):

- the percentage of cells in stages of mitosis was calculated
- the ratio of the number of cells in anaphase to the number of cells in metaphase was determined.

The results of the investigation are shown in Fig. 6.2.

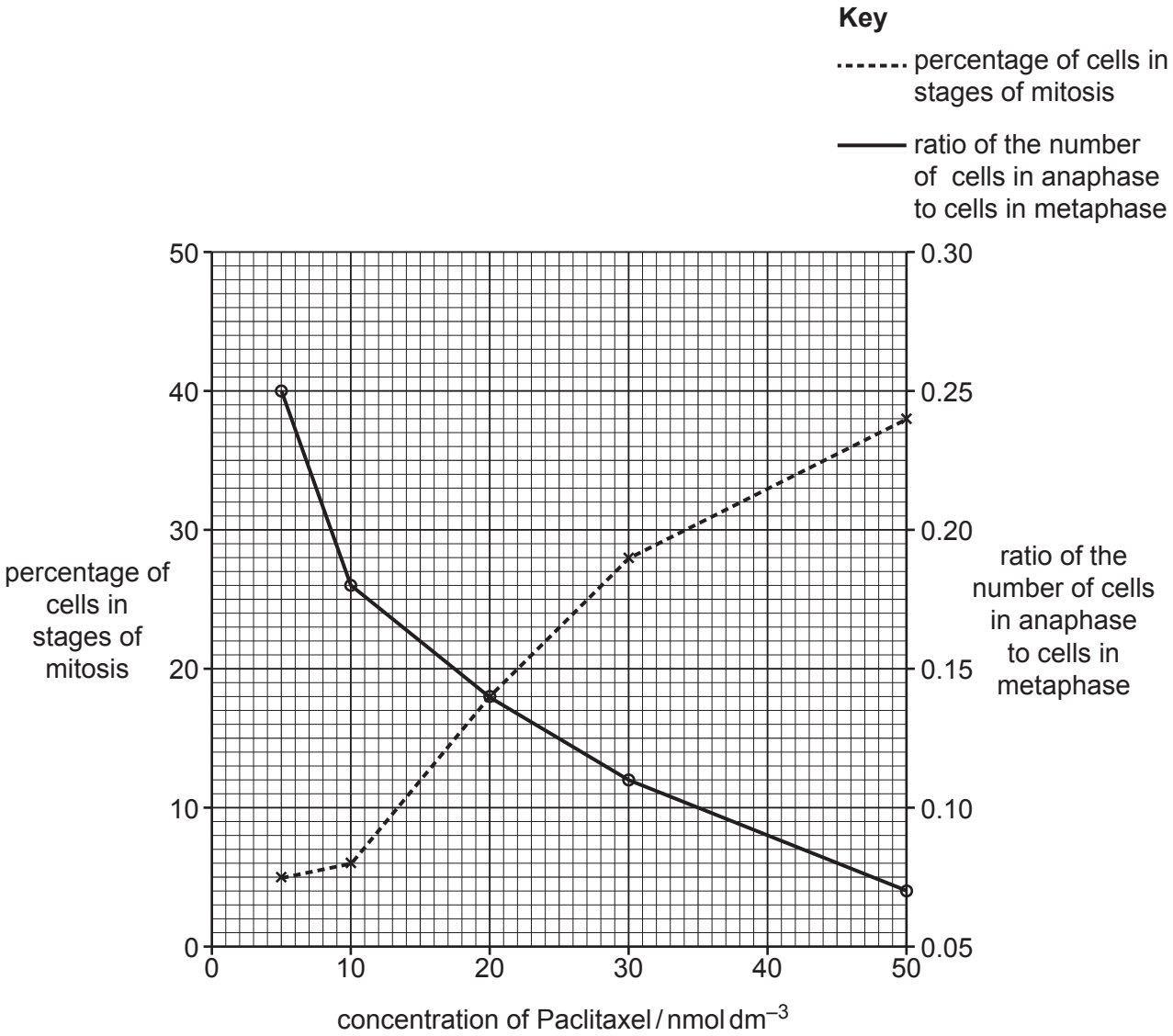

Fig. 6.2

With reference to Fig. 6.2, describe the results and suggest an explanation for the effect of Paclitaxel on the mitotic cell cycle.

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..... [4]

[Total: 7]

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4 The early development of an animal involves divisions of the zygote and daughter cells by mitosis to form an embryo consisting of genetically identical cells.

Fig. 4.1 shows several cells at various stages of the cell cycle in an embryo of whitefish, *Coregonus artedi*.

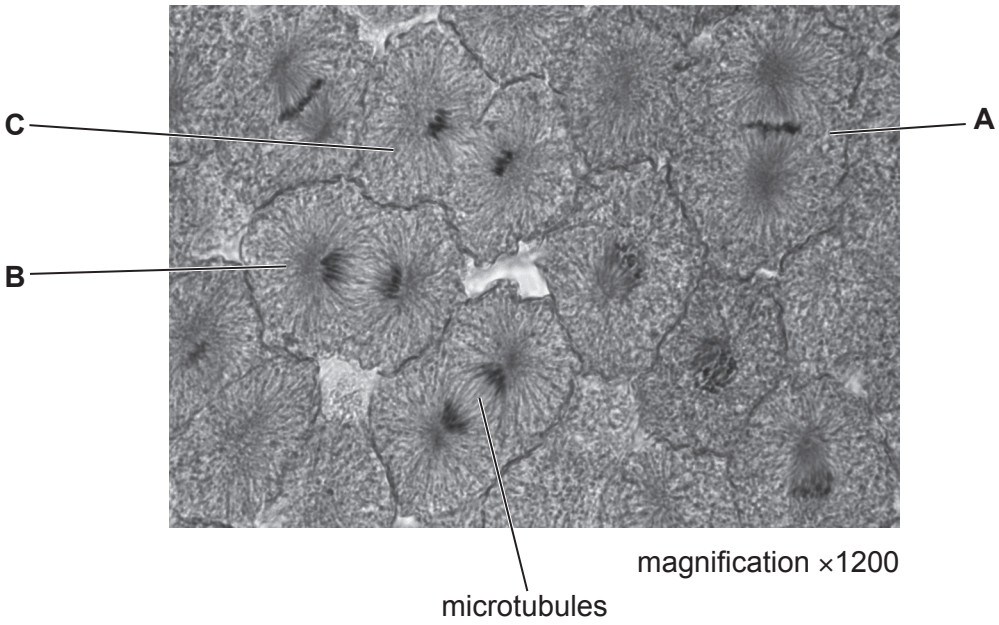

Fig. 4.1

(a) (i) Name the stage of mitosis in cell **A** and in cell **B**, shown in Fig. 4.1.

A .....

B .....

[2]

(ii) Fig. 4.1 shows microtubules in the cells that are dividing.

Describe the role of microtubules in mitosis.

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..... [3]

(iii) State what happens in cell **C**, shown in Fig. 4.1, until two new cells are formed.

.....

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..... [3]

(b) The cells produced in the developing whitefish are genetically identical.

Identify **and** explain **two** events that occur during the cell cycle that lead to daughter cells being genetically identical.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 11]

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(c) Mitogens are short chains of amino acids that function as cell-signalling molecules. Mitogens are released from secretory cells and travel in the blood to target cells, where the mitogens bind to cell surface receptors. The target cells respond by progressing from the G_1 phase to the S phase of the mitotic cell cycle.

(i) Outline what happens in the G_1 phase and S phase of the mitotic cell cycle.

G_1 phase .....

.....

.....

S phase .....

.....

.....
[2]

(ii) As a result of mutation, the production and release of mitogens into the blood can be greatly increased.

Suggest a possible consequence for target cells of increased concentrations of mitogens in the blood.

.....

.....

..... [1]

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4(c) Fig. 4.2 is a diagram of chromosome 11 at metaphase of mitosis.

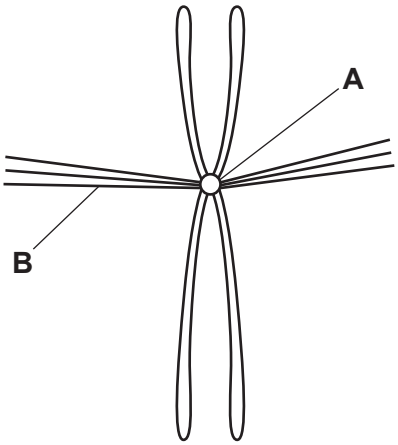

Fig. 4.2

(i) State the names **and** functions of structures **A** and **B**.

structure **A** .....

function .....

.....

structure **B** .....

function .....

.....

[2]

(ii) Complete Fig. 4.3 to show what happens to chromosome 11 in anaphase, so that the daughter nuclei are genetically identical.

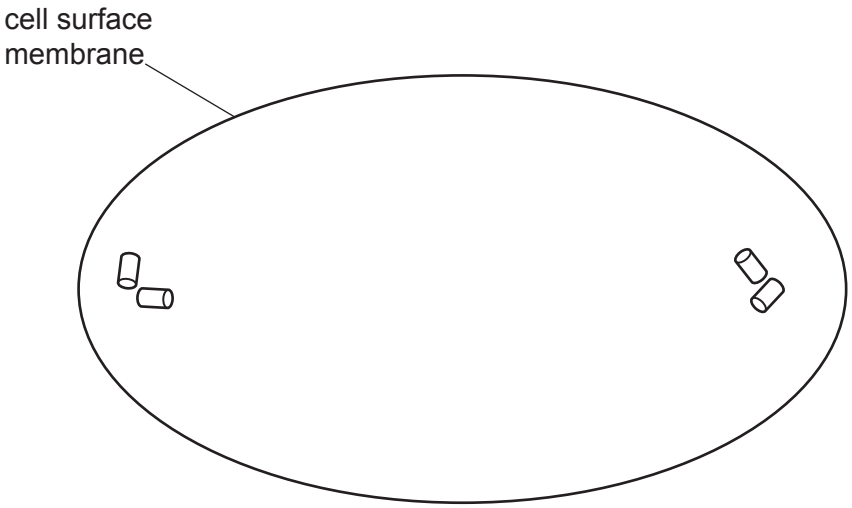

Fig. 4.3 [3]

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(c) The cell cycle can be divided into different parts.

Complete sentences **A**, **B** and **C** to provide more information about the mitotic cell cycle.

A The part of the cell cycle that occurs immediately after mitosis is

.....

B The part of the cell cycle in which the S phase occurs is

.....

C The main event that occurs during the S phase is

.....

[3]

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1 The cells in a tissue are often at different stages of the cell cycle.

(a) Fig. 1.1 shows cells at different stages of the cell cycle.

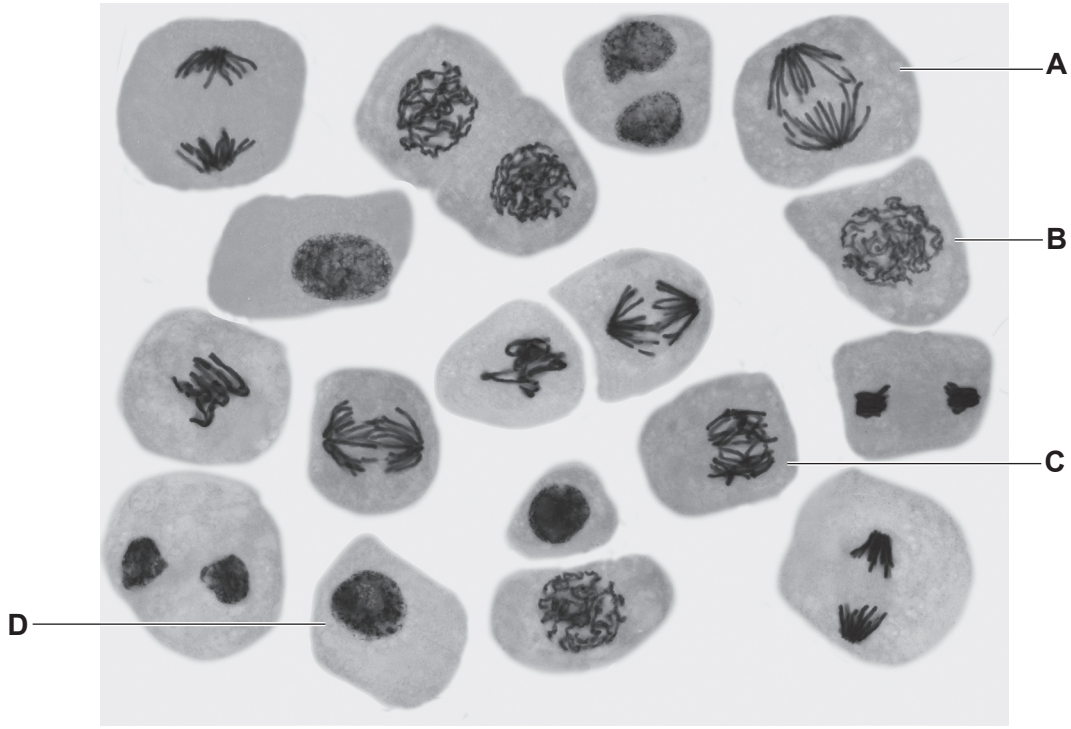

Fig. 1.1

(i) Identify the stages of mitosis occurring in the cells labelled **B** and **C** in Fig. 1.1.

B .....

C .....

[2]

(ii) Describe the behaviour of the chromosomes in the stage of mitosis shown in cell **A** in Fig. 1.1.

.....

.....

.....

.....

.....

.....

..... [3]

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(b) Telomerase is an enzyme that is active during interphase in some cells.

Telomerase helps to maintain telomeres present on chromosomes.

(i) State the location of telomeres on a chromosome.

.....

..... [1]

(ii) Some people with a long lifespan have cells showing a higher than normal activity of telomerase.

Suggest why a long lifespan could result from a higher telomerase activity.

.....

.....

.....

.....

..... [2]

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1 The malarial pathogen, *Plasmodium falciparum*, enters red blood cells after a person becomes infected. After some time, each cell of *P. falciparum* divides to form daughter cells.

Fig. 1.1 shows a cell of *P. falciparum* that is forming many daughter cells.

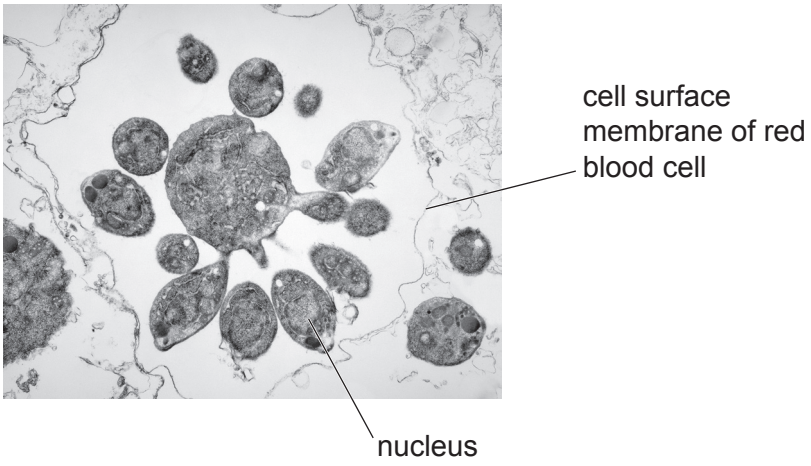

Fig. 1.1

(b) When *P. falciparum* divides there is unequal division of the cytoplasm to form small, genetically identical daughter cells.

Outline the events that occur in the cell of *P. falciparum* to form the daughter cells shown in Fig. 1.1.

.....

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.....

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..... [3]

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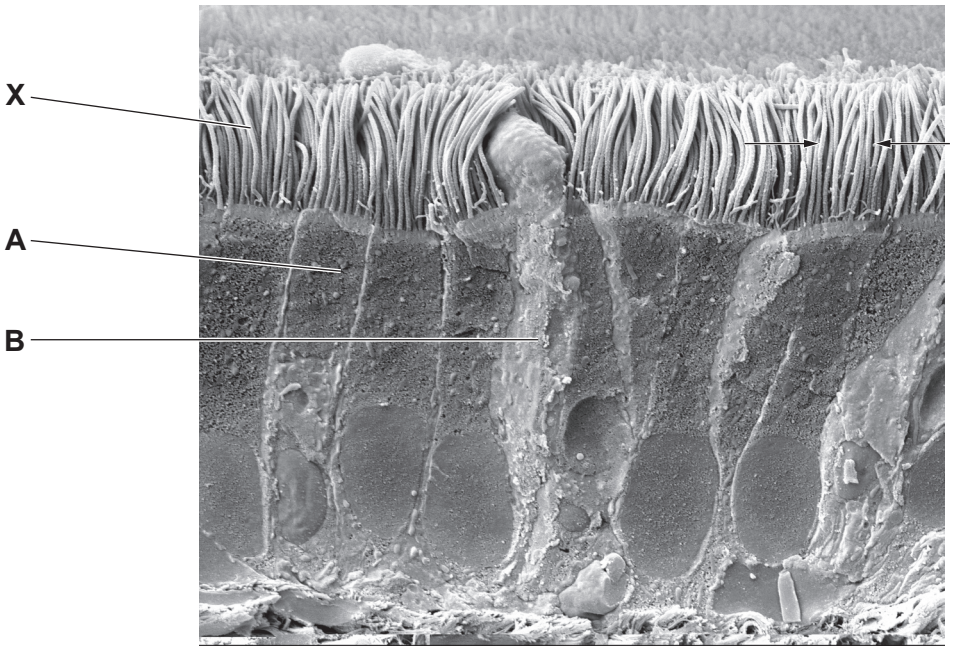
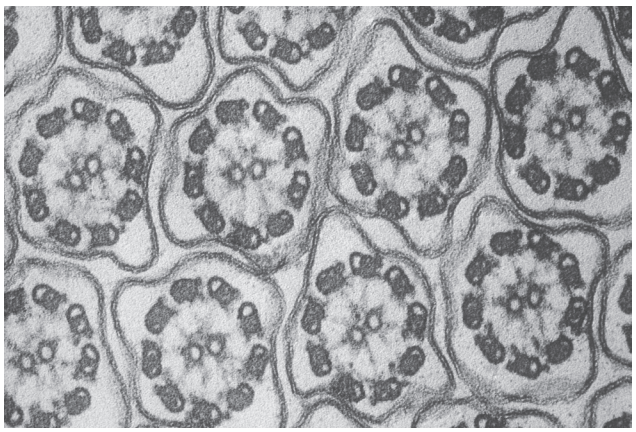
4 Fig. 4.1 is a scanning electron micrograph showing the tissue that lines the bronchi in the gas exchange system.

Fig. 4.2 is a transmission electron micrograph of a horizontal section made at the position indicated by the two arrows in Fig. 4.1.



magnification ×3000

Fig. 4.1



magnification ×80 000

Fig. 4.2

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(c) Stem cells are found in the lining of the bronchi.

Describe the function of centrioles **and** explain how they are involved in the cell cycle of a stem cell.

.....

.....

.....

.....

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.....

.....

..... [4]

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5 During interphase of the cell cycle, individual chromosomes cannot be seen within the nucleus. The genetic material is termed chromatin during this stage.

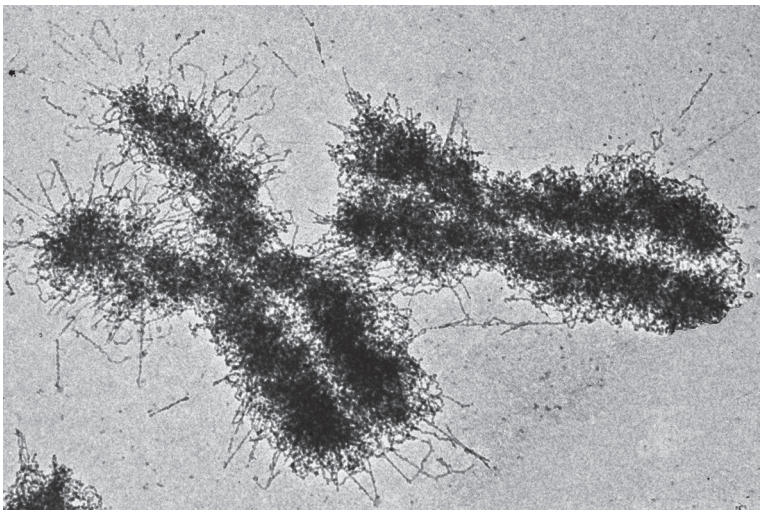
(a) Changes occur to chromatin during mitosis so that chromosomes become visible.

State what happens to chromatin so that individual chromosomes can be seen during mitosis.

.....

..... [1]

(b) Fig. 5.1 is a transmission electron micrograph of two human chromosomes at metaphase of mitosis.



magnification = ×14 000

Fig. 5.1

Describe the structure of chromosomes at metaphase, such as the two chromosomes shown in Fig. 5.1.

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 5]

5 Cyclin-dependent kinases (CDKs) are enzymes that regulate the cell cycle.

(a) Cell signalling by ligands causes the activation of CDKs in target cells.

Outline the main stages in the process of cell signalling by ligands that can cause specific responses in target cells.

.....

.....

.....

.....

..... [2]

(b) The activity of CDKs is reduced by CDK inhibitors. Many of these inhibitors occur naturally in cells.

Fig. 5.1 is a diagram of a CDK inhibitor binding to a CDK molecule.

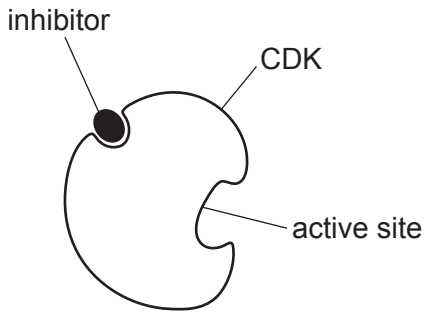


Fig. 5.1

State **and** explain how the CDK inhibitor in Fig. 5.1 prevents the activity of the CDK molecule.

.....

.....

BASED UPON TOPIC 3

.....

.....

..... [2]

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(c) Table 5.1 lists three different CDKs, their roles in the cell cycle and molecules that inhibit them.

Table 5.1

name of CDK	role of CDK in the cell cycle	CDK inhibitor
CDK1	regulates cell progression from G_2 to mitosis	RO-3306
CDK2	regulates the processes of the S phase	p21Cip1
CDK4	regulates cell progression from G_1 to the S phase	palbociclib

(i) With reference to Table 5.1, state which CDK inhibitor is likely to result in a cell containing **one** chromatid per chromosome. Explain your answer.

inhibitor .....

explanation .....

.....

LINKS WITH TOPIC 3

[2]

(ii) With reference to Table 5.1, state which CDK inhibitor is likely to result in a cell with:

- a relatively high concentration of mitochondria
- **two** chromatids per chromosome.

Explain your answer.

inhibitor .....

explanation .....

.....

.....

LINKS WITH TOPIC 3

[2]

(d) Scientists have developed CDK inhibitors that are synthetic.

Explain why CDK inhibitors can be used to treat cancerous tumours.

.....

.....

.....

..... [2]

[Total: 10]

6 Fig. 6.1 shows a plant cell in a stage of mitosis.

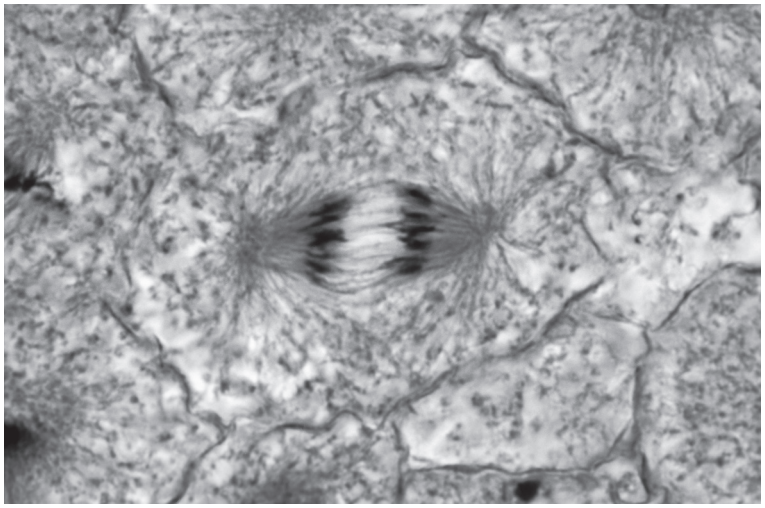


Fig. 6.1

(a) Some of the structures shown in Fig. 6.1 contain DNA.

Use a line labelled **D** on Fig. 6.1 to indicate **one** of these structures. [1]

(b) Name the stage of mitosis shown in Fig. 6.1.

..... [1]

(c) Colchicine is a chemical used by scientists to study mitosis. This chemical inhibits the organisation of the microtubules in prophase of mitosis.

The cell shown in Fig. 6.1 had **not** been treated with colchicine.

Explain the evidence in Fig. 6.1 that shows the cell had **not** been treated with colchicine.

.....

.....

.....

.....

.....

..... [2]

[Total: 4]

4 Adult stem cells are undifferentiated cells that are found in most animal tissues.

Adult stem cells can divide by mitosis throughout their lifespan to form identical stem cells (self-renewal) or to form cells that can differentiate into the functioning cells of that tissue.

(a) Mitosis is important for the repair of tissues.

Explain what is meant by repair of tissues.

.....

.....

..... [1]

(b) Uncontrolled cell division is a characteristic feature of tumour formation from a differentiated cell.

Describe **other** features of tumour formation from a fully differentiated cell.

.....

.....

.....

.....

..... [2]

(c) Telomeres prevent loss of genes.

Adult stem cells have chromosomes with long telomeres.

Explain why long telomeres are an advantage to cells that carry out many cell cycles.

.....

.....

.....

.....

.....

..... [2]

Haematopoietic stem cells (HSCs) are adult stem cells that are located in the bone marrow of bones. HSCs have a role in the formation of blood cells.

Fig. 4.1 is an outline summary showing the formation of some of the different types of blood cell that can be formed from HSCs. The first stage is the division of HSCs to produce progenitor cells. These cells are also able to divide by mitosis, but are **not** stem cells.

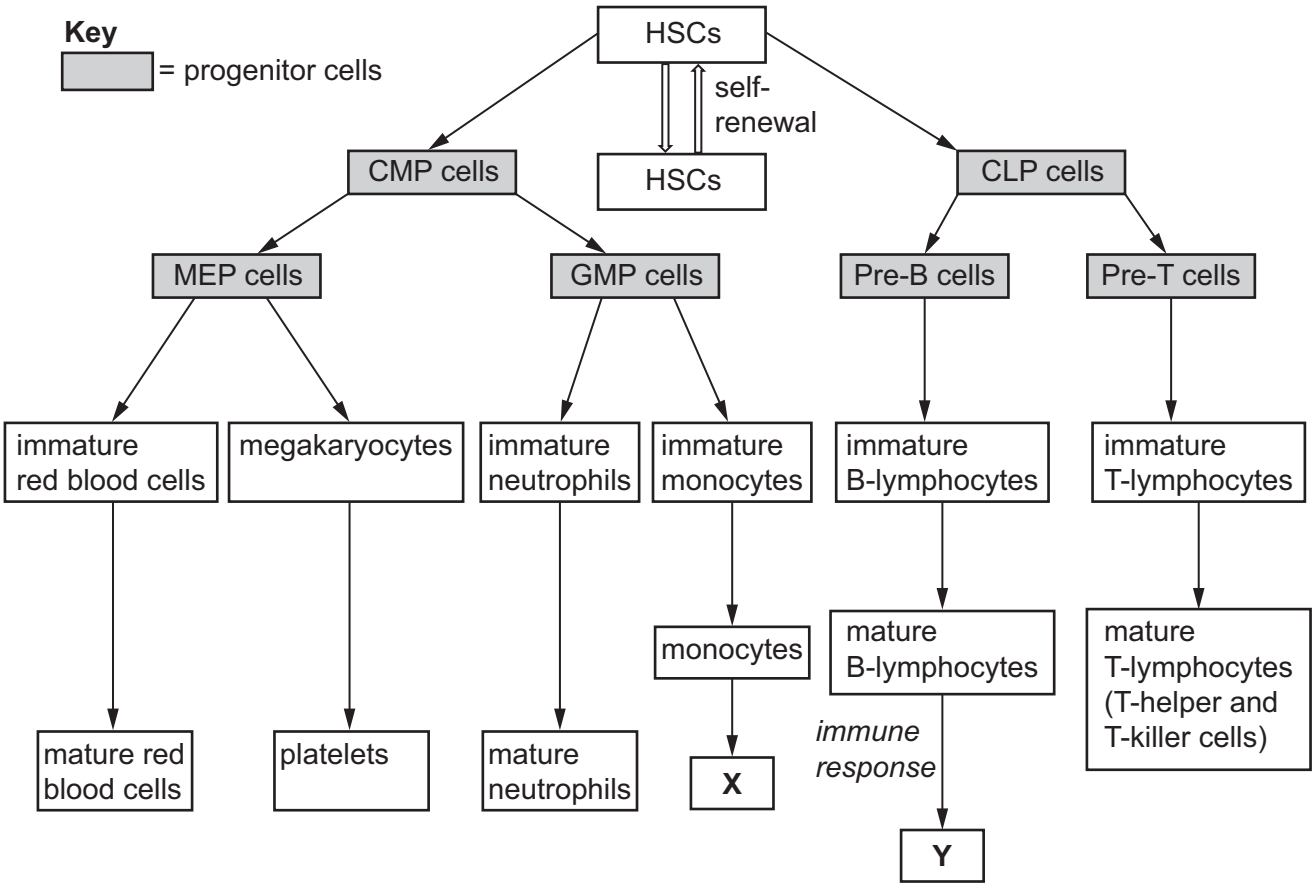


Fig. 4.1

(d) With reference to Fig 4.1, explain why GMP cells, which are progenitor cells, **cannot** be described as haematopoietic stem cells (HSCs).

.....

.....

.....

.....

.....

.....

..... [3]

2 Stem cells are found throughout the human body. $Lgr5^+$ stem cells are found in the lining of the small intestine.

Fig. 2.1 is a flow chart showing stages in the development of one of the daughter cells produced by the mitotic division of an $Lgr5^+$ stem cell.

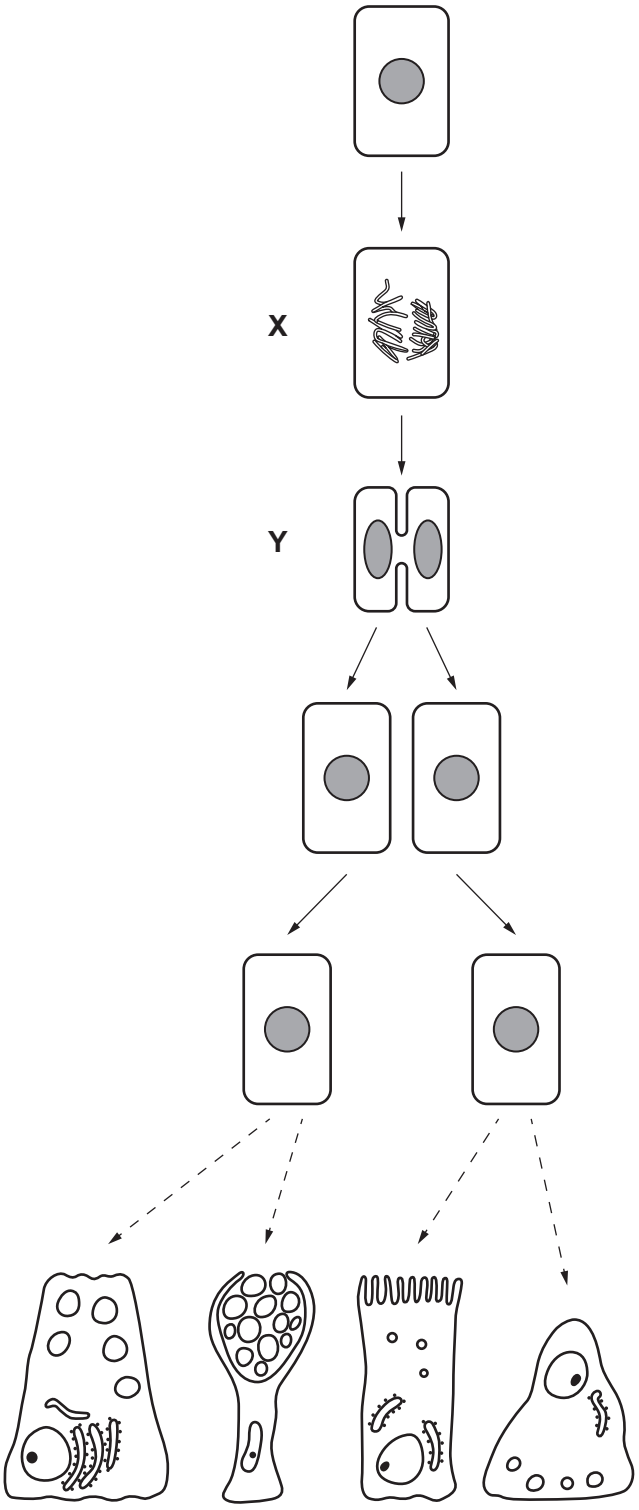


Fig. 2.1

(a) **(i)** Explain why stem cells are required in places such as the lining of the small intestine.

.....

.....

.....

.....

..... [2]

(ii) Name the stage of mitosis shown in cell **X** in Fig. 2.1.

..... [1]

(iii) State the part of the cell cycle shown at **Y** in Fig. 2.1.

..... [1]

(b) Explain the role of centromeres in the cell cycle.

.....

.....

.....

.....

..... [2]

6 **(a)** Fig. 6.1 shows photomicrographs of individual cells from the root tip of an onion, *Allium sp.*, at different times in the mitotic cell cycle.

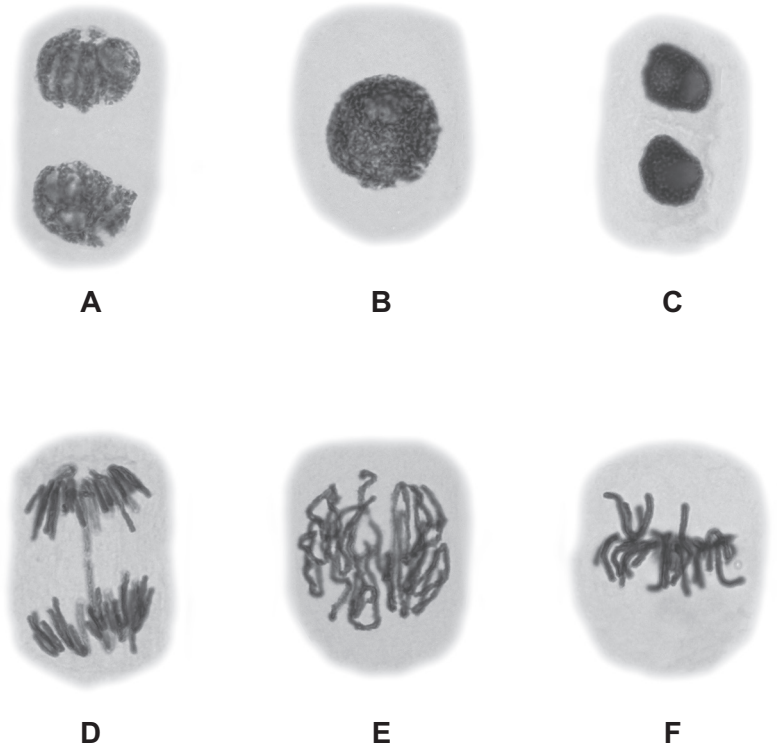


Fig. 6.1

(i) Place the letters representing the individual cells in the correct sequence of the mitotic cell cycle. The first letter has already been filled in.

B					

[1]

(ii) Cell **A** in Fig. 6.1 is in one of the main stages of mitosis.

Describe the events that occur during this main stage of mitosis.

.....

.....

.....

.....

..... [2]

(b) Complete Table 6.1 by stating the term that matches each of the descriptions.

Table 6.1

term	description
	region of DNA with repeated nucleotide sequences located at the ends of chromosomes
	organises microtubules to form the spindle in animal cells
	point of attachment between two sister chromatids

[3]

[Total: 6]

Biology 9700-Paper 2 Year 2025 (M/J) Variant 24

1 In the roots of plants, specialised tissues are formed from a region in the root tip known as the root apical meristem.

Fig. 1.1 shows the different regions of a root tip.

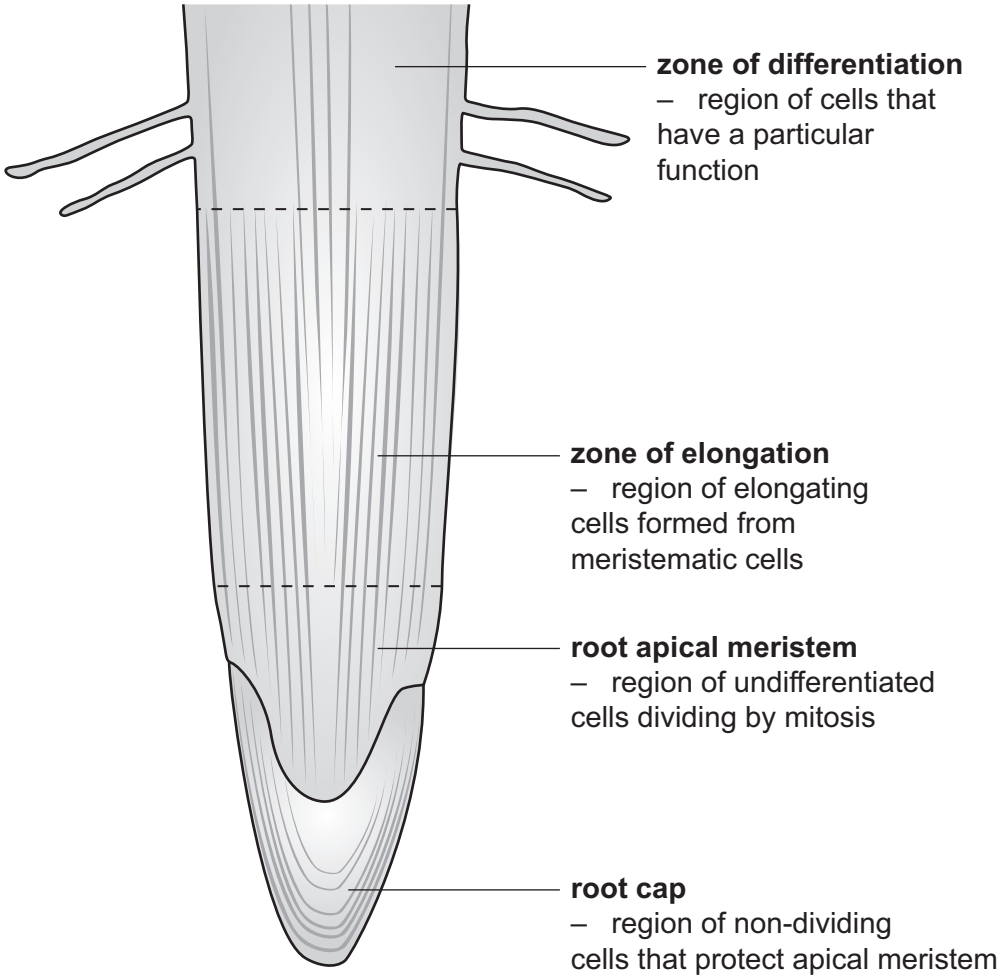


Fig. 1.1

(a) Cells in all stages of mitosis will be visible in the root apical meristem by using the high power of a light microscope.

(i) Name the stage of mitosis during which the chromosomes are arranged at the spindle equator of the cell.

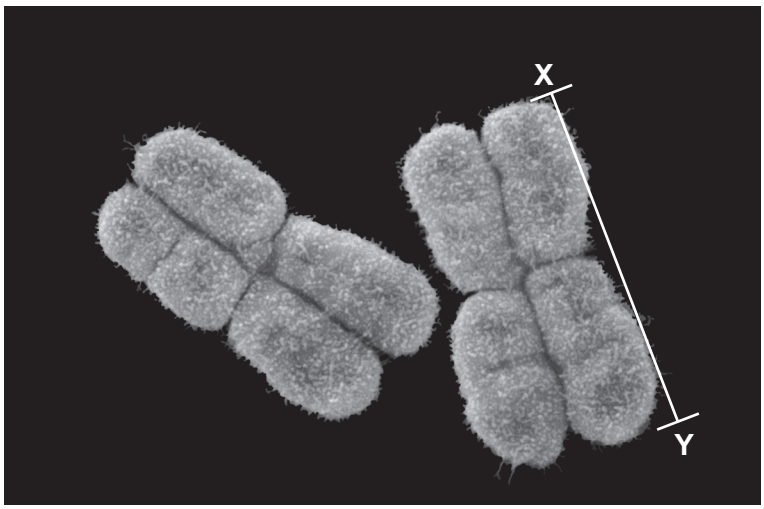
..... [1]

(ii) Early in mitosis, the nuclear envelope breaks up into vesicles and so will not be seen in some cells in the root apical meristem.

Name the stage of mitosis during which the vesicles fuse to form new nuclear envelopes.

..... [1]

3 Fig. 3.1 is a scanning electron micrograph of a pair of human chromosomes in a stage of the mitotic cell cycle.



magnification ×8625

Fig. 3.1

(c) With reference to Fig. 3.1, explain how it is possible to deduce that DNA replication has already occurred.

.....

.....

..... [1]